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NEW ZEALAND INSTITUTE.

NOTICE TO MEMBERS.

The publications of the New Zealand Institute consist of—

1. **Transactions,** a yearly volume of scientific papers read before the local Institutes. This volume is of royal-octavo size, and is issued on the 1st June of each year.

2. **Proceedings,** containing reports of the meetings of the Board of Governors of the New Zealand Institute and of the local Institutes, abstracts of papers read before them and of papers dealing with New Zealand scientific matters and published elsewhere, list of members, &c. The Proceedings are of the same size as the Transactions, and are issued in three or four parts during the year as may be required. In addition to the copies of the Proceedings distributed during the year, an additional number is printed and a complete set for the year is bound up with the yearly volume of Transactions supplied to members.

   The Transactions and Proceedings are posted direct to members of the Institute from the Printing Office. For this purpose the Secretaries of the local Institutes must, before the 1st January in each year, forward a list of members, with addresses, to the Secretary of the New Zealand Institute, and see that it is corrected from time to time when necessary. It is the duty of members to inform the Secretary of their local Institute of any change in their address.

3. **Bulletins.** Under the title of "Bulletins" the Board of Governors hopes to be able to issue from time to time important papers which for any reason it may not be possible to include in the yearly volume of the Transactions. The bulletins are of the same size and style as the Transactions, but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

MEMORANDUM FOR AUTHORS OF PAPERS FOR TRANSACTIONS AND PROCEEDINGS OF THE NEW ZEALAND INSTITUTE.

In order to facilitate the printing, and thus save both time and money, particular attention is requested to be paid to the following details :—

1. All papers must be typewritten, unless special permission to send in written papers has been granted by the Editor for the time being.

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3. A badly arranged or carelessly composed paper must be sent back to the author for amendment by the Council of the society before which it was read. It is not the duty of an editor to amend either bad arrangement or defective composition.

4. In regard to underlining of words, it is advisable, as a rule, to underline only specific, generic, or family names, or foreign words.

5. In regard to specific names, the International Rules of Zoological Nomenclature in relation to zoological names, and the International Rules for Botanical Nomenclature, must be adhered to.

6. Titles of papers should give a clear indication of the scope of the paper, and such indefinite titles as, *e.g.*, "Additions to the New Zealand Fauna" should be avoided.

7. Papers should be as concise as possible, all unessential details being omitted.

8. Photographs intended for reproduction should be the best procurable prints, unmounted and sent flat.

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12. In accordance with a resolution of the Board of Governors, authors are warned that previous publication of a paper may militate against its acceptance for the Transactions.

13. In ordinary cases twenty-five copies of each paper are supplied gratis to the author, and in cases approved of by the Publication Committee fifty copies may be supplied without charge. Additional copies may be obtained at cost-price.

By order of the Board of Governors.

Royal Society of New Zealand

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AND

PROCEEDINGS

of the Royal Society of New Zealand

OF THE

NEW ZEALAND INSTITUTE

1911

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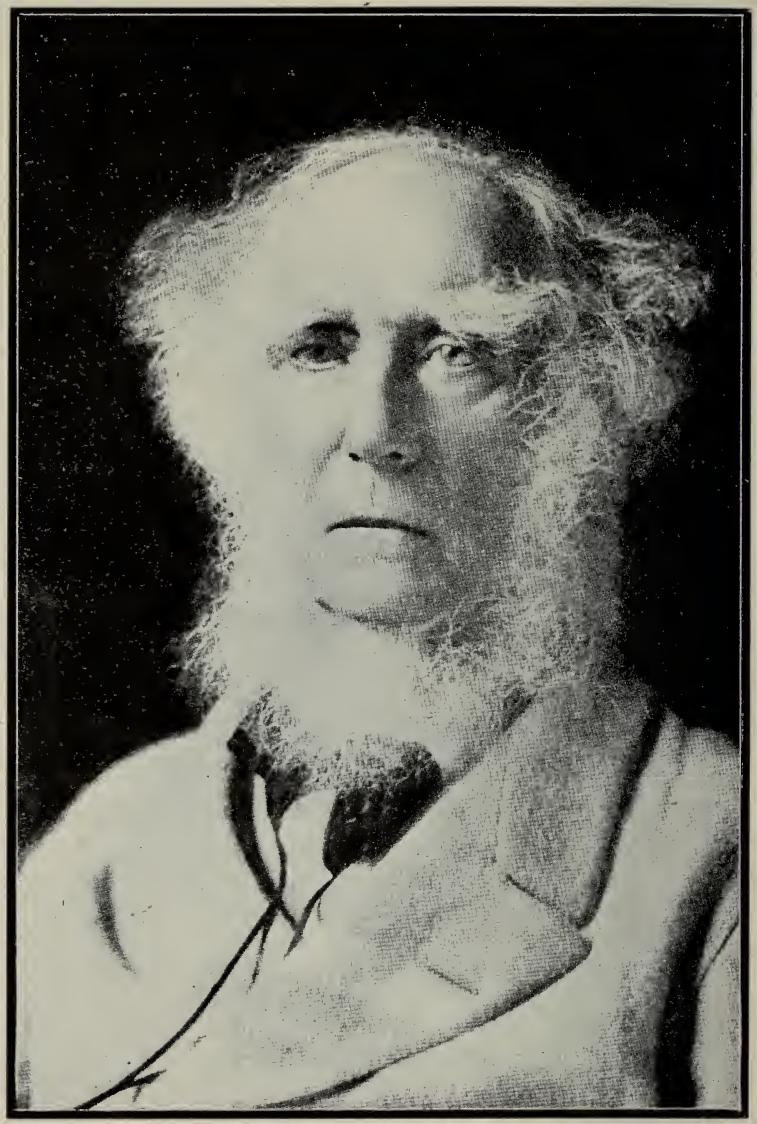

[*After portrait in Kew Bulletin.*

SIR JOSEPH DALTON HOOKER, O.M., F.R.S.

OBITUARY.

SIR JOSEPH DALTON HOOKER, O.M., F.R.S.

(1817-1911.)

Through the lamented death of Sir Joseph Hooker, the greatest of British botanists, the New Zealand Institute has lost not only the most illustrious and revered of its honorary members, but one whose hand has laid an impress on New Zealand science never to be effaced.

Hooker's connection with New Zealand botany commenced so long ago as the early summer of 1840, when, as naturalist to the famous Antarctic Expedition under Sir James Ross, he explored botanically the Auckland and Campbell Islands. How thoroughly this work was conducted is evidenced by the fact that, notwithstanding subsequent visits of several experienced botanists and one well-equipped scientific expedition, only twenty-five additions, many of which are doubtless extremely local, have been made to Hooker's original list of 124 species of vascular plants. As for the lower cryptogams (277 species), they remain virtually as they were. Three months (August–November) of the succeeding year were spent by Hooker at the Bay of Islands, where he made a collection of about three hundred species, and gained at the same time a first-hand acquaintance with a portion of the New Zealand flora proper. Perhaps even more important was his meeting Colenso, who, through contact with the brilliant young botanist, was stirred up to that life-long enthusiastic devotion to science which yielded such valuable results.

Immediately on the return of the Ross Expedition Hooker commenced the study of his collections, and, notwithstanding their magnitude, the first volume of the magnificent "Flora Antarctica," devoted to the New Zealand Subantarctic Islands, appeared in 1844, and marked the commencement of a new epoch in New Zealand botany.

The years 1853 to 1855 saw the publication of the "Flora Novae-Zelandiae," a quarto work in two volumes similar to the "Flora Antarctica," consisting of 729 pages and 130 coloured plates. In this and the last-mentioned work the species are not merely described, but their affinities and geographical distribution most thoroughly considered. Further, the essay on the New Zealand flora which formed an introduction to the "Flora Novae-Zelandiae" is a phytogeographic classic of the highest excellence. Written presumably to educate the colonial collector and to stimulate botanical research in the new colony, it deals in a most searching manner with the origin and affinities of the flora, and as a contribution to philosophical plant-geography has never been excelled in its admirable marshalling of the facts, clearness of style, moderation of tone, and carefully balanced conclusions. Another portion of the essay, treating of the limits of species, their dispersion and variation, is full of matter interesting even yet to a present-day student of evolution.

Hooker's investigations in New Zealand botany extended far into the "sixties," when his "Handbook of the New Zealand Flora" (1864–67) appeared. This was no mere reproduction of his former works, for many colonial collectors had been hard at work (Colenso, Travers, Haast, Hector, Buchanan, &c.), and a vast quantity of fresh material awaited examination. Indeed, the task was one of no small magnitude, and when the marvellous accuracy of the descriptions is considered it is hard to believe the fact that they were drawn up from herbarium material alone. Assuredly, well might Darwin exclaim, "Oh, my heavens! to get up at second hand a New Zealand flora—that is work." How original the treatment was is shown by Hemsley's computation that sixteen endemic genera and half the species described have the affix "Hook. f."

The indebtedness of New Zealand science does not end with Hooker's published work. To all serious investigators of the flora he was a friend, guide, and counsellor. There is, indeed, no name of moment in the later botany of the Dominion but is deeply indebted to Hooker's influence and assistance, generously given.

Almost to the last did the great botanist feel keen interest in the progress of knowledge in that far-off region where his spurs had been won. Writing to the Council of the Canterbury branch of the Institute on the 24th June, 1910, he said, in reference to the recently published "Subantarctic Islands of New Zealand," "I was aware of the scientific expedition to the Auckland and Campbell Islands organized in 1907, and was looking anxiously for some records of its results." After explaining that, of course, he was specially interested in the botany, he adds, "There is really no section, biological and geological, which I can afford to overlook."

Hooker's work on New Zealand botany, to which the above sketch does but scant justice, extending over a period of nearly forty years, reflects but a portion of that genius and untiring industry which have so strongly influenced botanical research throughout the Empire.

L. Cockayne.

H. C. FIELD.

Henry Claylands Field was born at Holybourne, Hampshire, England, in 1825. He received his education at Stockwell Grammar School and the City of London School, and completed the scholastic portion of his life by a course at King's College, London.

Being destined for the profession of a civil engineer, he was articled to Sir John Rennie, whose name is well known all over the world in connection with great works of engineering, and who was the builder of the present London Bridge.

At the age of twenty Mr. Field entered the service of an English railway company, where he remained for ten years. The colonies then attracted him, and he came out to New Zealand in the ship "Simla," and proceeded to Wanganui. The young settlement was then governed by a Town Board, which appointed Mr. Field its Clerk and Engineer. Subsequently he acted also as Engineer to the Road Boards of the district, and as Consulting Engineer to the Rangitikei Road Board.

By the construction of good communications Mr. Field left his mark all over the district, being responsible for the construction of no less than two thousand miles of roads. His name is perpetuated by Field's Track from Wanganui to Karioi, the half of which nearest to Wanganui now forms part of the Parapara Road. This track has been and is still used by thousands, and is known as one of the best surveyed and graded roadways in the country, even though part of it never got beyond the track stage. In 1884 Mr. Field retired from active pursuits.

He published several papers on scientific subjects, and a book entitled "Ferns of New Zealand," which gives a popular account of the ferns of these Islands and its immediate dependencies, and is noted for its good descriptions and excellent illustrations.

He was an ardent supporter and exhibitor of the Horticultural Society, and took a great interest in harbour matters and public affairs generally.

He died at Aramoho, Wanganui, at the advanced age of eighty-seven years.

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TRANSACTIONS.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE,

1911.

Art. I.—*Observations concerning Evolution, derived from Ecological Studies in New Zealand.*

By L. Cockayne, Ph.D., F.L.S.

[*Read before the Philosophical Institute of Canterbury, 2nd August, 1911.*]

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I. Introduction.

Plant-ecology is concerned with the study of plants as living organisms, not in the laboratory under artificial conditions, but in the field as they grow naturally. Like every branch of a great science, its content is not bounded by any definite limits, but it intergrades with various departments

of botany, especially physiology and floristic botany, though its methods are different from those of the latter.

The conditions which the earth offers, in its manifold soils and climates, for plant-life are extremely diverse and complex, but nevertheless there exists in no few instances an apparent harmony between the conditions and the plants, which is manifested in the latter by some special form either of the organism as a whole or of one or more of its organs. It is obvious that in attempting to correlate plant-forms with their environmental factors matters are being dealt with which deeply affect the study of descent, and data are accumulated which cannot be neglected by students of general evolution.

But besides being occupied by plant-adaptations* the ecologist has also to do with the species of the taxonomist, since for one part of his work, at any rate, the groups of individuals indicated by the specific names are at present the units with which he has to deal. Furthermore, his practical acquaintance with such species, and particularly with their varieties, must in course of time become wide, while a variation with him is not merely a taxonomic mark to be noted for purposes of classification, but a physiological expression to be explained.

Besides being concerned with the origin of adaptations and species, plant-ecology deals with the arrangement of the latter into the various more or less well-defined combinations entitled "plant-associations," and here come in such fundamental evolutionary concepts as distribution, isolation, and the struggle for existence.

Plant-ecology itself, although studied in a more or less desultory and incoherent fashion since the time of Linnaeus, may be said to date, as a special branch of botany, from the publication of Warming's Plantesamfund in 1895.† At first looked at askance by the older botanists, it has steadily advanced in importance. It is prosecuted by careful and enthusiastic workers in many lands, and is now almost universally recognized as a field of the highest biological moment. Unfortunately, its methods are for the most part extremely crude, there is but little uniformity of procedure amongst its adherents, and its nomenclature is altogether unfixed. Lastly, many of the problems that await solution are amongst the most difficult that science has to offer.

Bearing the above statements in mind, it is obvious that the simpler the conditions and the fewer the species involved, the easier is it to draw conclusions of moment, and to state the ecological "facts," if one may so designate what arise from observations made under conditions far from stringent. Also, *a virgin vegetation alone can give definite information on many topics.* The New Zealand biological region supplies in some measure the above desiderata. Its vascular flora, consisting of some 1,650 species, is not too great for an ecological worker to grasp; its vegetation is still in many places absolutely virgin; its climate varies from subtropical to subantarctic;‡ some parts experience an annual rainfall of more than

---

* The convenient term "adaptation" is used throughout this paper in a non-teleological sense.

† This statement applies rather to the ecology of plant-distribution than to that general and more fundamental study of life-reactions known as "biology" by German investigators. In this latter sense Darwin himself stands pre-eminent as an ecologist.

‡ The subantarctic and the subarctic climates are by no means identical. Intense cold plays no part in the first-named, its main characteristics being lack of sunshine, frequent cold gales, constant showers, and a low average temperature all the year, with but little frost in winter.

500 cm. and other parts less than 30 cm.; the plant formations include mangrove swamp, rain forest, heaths of various kinds, subglacial fell- and herb-fields, varied associations of rock and debris, subantarctic southern-beech forest, associations in and near hot springs, dunes, salt meadows, steppes, swamps, and moors—in fact, for an equal variety an ecologist would have to explore one of the larger continents in its entirety. Further, the isolation of the region for a vast period of time far from any other land-surface; the absence of grazing animals, the moa (*Dinornis*) excepted; the diverse floral elements (Malayan, Australian, Subantarctic, &c.); the strong endemism; the numerous small islands where conditions are simpler than on the larger ones; and, finally, the presence of many areas whose vegetation has been changed within a very few years through the farming operations of the settler, and its components replaced by exotics of quite different growth-forms—all these attributes much enhance the importance of New Zealand for ecological research.

Now, although I well know that the final court of appeal in evolutionary matters is experiment, still it seems to me that some few details having a bearing on various phases of the evolution question selected from numerous observations on a vegetation and a flora that one may venture to designate "unique" may perhaps be worth the attention of students of descent.

II. Elementary Species.

Few will deny, whatever be their opinions as to its truth, that the most awakening contribution of late years to the evolution question has been the mutation theory of De Vries. Leaving out of consideration for the present the value of the theory as a means of evolution, the introduction of careful experimental methods—*i.e.*, a return to Darwin's own procedure—rather than mere argument in favour of this or that dogma has given new life to the study of evolution. Moreover, a change of the highest moment is the substitution of elementary species* as the raw material for the evolutionary process, rather than the Linnean species, which, as shown below, *are frequently ideas merely and not living entities.* It seems well, then, first of all to examine how far the doctrine of elementary species is supported by the New Zealand flora, as interpreted by ecology.

It need hardly be pointed out that the species of New Zealand taxonomists belong to the Linnean category, and that, while some refer to definite and well-defined groups the individuals of which can be recognized at a glance (*e.g.*, *Veronica Gilliesiana* T. Kirk, *Senecio cassinioides* Hook. f., *Carmichaelia gracilis* J. B. Armstg., *Urtica ferox* Forst. f.), others vary to such an extent that there is no special set of individuals reproducing a plant that matches the specific description, which is drawn up so as to include a varying series of forms† which are considered to intergrade (*e.g.*, *Veronica salicifolia* Forst. f., *Celmisia coriacea* Hook. f., *Asplenium bulbiferum* Forst. f., *Danthonia semiannularis* R. Br., and, roughly speaking, perhaps 25 per cent of the vascular flora). Such "species" as these latter do not really exist; *they are ideas only, and their origin has nothing to do with evolution.* Other "species," again, through want of a full knowledge of their

* This is not very different, after all, from Darwin's view, who declared that "a well-marked variety may therefore be considered an incipient species . . . the term 'species' is one arbitrarily given to a set of individuals closely resembling each other, and that it does not essentially differ from the term 'variety.'" (Darwin, 1899, p. 39.)

† And then accepting this as a species, it is said to be "extremely variable."

forms, &c., may include even more than one Linnean species, as appears to be the case with *Pittosporum rigidum* Hook. f., as defined by Hooker, Kirk, and Cheeseman. Plate I shows this case clearly, where the type of *P. rigidum* on the right differs most markedly from the common South Island form on the left, which I am naming *P. divaricatum*.*

In some cases the difficulty as to distinguishing-names is met by the "creation" of "varieties"; but *these, again, are of quite different values, and may belong to distinct biological categories.* A few examples taken from the "Manual of the New Zealand Flora" (Cheeseman, 1906) will explain my meaning.

1. *Hoheria populnea* A. Cunn. (p. 78) is divided into the three varieties—(*a*) *vulgaris* Hook. f., (*b*) *lanceolata* Hook. f., and (*c*) *angustifolia* Hook. f. There is no such plant in existence as *H. populnea*, for the description includes the three varieties (*a*), (*b*), and (*c*), each of which, however, is distinguished by a special diagnosis, the varieties (*a*), (*b*), and (*c*) respectively representing distinct groups of individuals which reproduce themselves true from seed.

2. *Carmichaelia Enysii* T. Kirk has a variety *orbiculata* T. Kirk (p. 111). Both the species and its variety are described. But in this case the specific description refers to one set of individuals possessing certain characters, which is *C. Enysii* proper, and does not include var. *orbiculata*, which is to be recognized through its having other characters absent in *C. Enysii* proper, which latter may then be termed the type.

3. *Epilobium junceum* Sol. has vars. *cinereum* Hausskn., *hirtigerum* Hook. f., and *macrophyllum* Hausskn., each of which is defined at considerable length (p. 175). But none of these names represents a biological entity, for *E. junceum*, to quote from Cheeseman, "is an extremely variable plant, the numerous forms of which may be grouped in the three following varieties"—*i.e.*, as above. Further he writes, "The extreme states of the above varieties have a very distinct appearance, and might have been treated as species were they not connected by numerous intermediate forms, which make it quite impossible to draw strict lines of demarcation between them." Here, then, the description of the species does not indicate a type, but it includes *the three varieties and all the intermediate forms*, while the varieties themselves are likewise not distinct entities,† and belong to a different biological category to the var. *orbiculata* of *C. Enysii*.

4. *Gaultheria rupestris* R. Br. (p. 407) is a similar example to the last, being said to be "a highly variable plant, the numerous forms of which are best arranged under two heads"—namely, var. *lanceolata* Cheesem. and var. *parvifolia* Cheesem.

5. In certain other cases, where there are a host of intergrading forms, the most divergent are treated as separate species notwithstanding that they are connected by intermediates. An example of this is *Veronica pinguifolia* Hook. f. and *V. Buchanani* Hook. f., of which latter species Cheeseman writes (p. 527), "Larger forms approach *V. pinguifolia* so closely that it is difficult to draw a line of demarcation between the two species. My var. *major* might be referred to either." Other examples of similar

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* It seems possible also that *P. divaricatum* consists of two elementary species, found in the steppe and forest climates of the South Island respectively. See Plate VIII, and compare it with the figure in Diels (1906).

† Biologically some are certainly distinct entities, as, *e.g.*, the variety *macrophyllum*, which Petrie has "made" into a species under the name *E. erectum*, and which is greatly on the increase where forest is being removed in the Waimarino locality.

Example of a Taxonomic Species.

On right and left, adults of *Pittosporum rigidum*, not distinguished as varieties: in centre, juvenile form of plant on right.

Fig. 1.—Three Forms of the "Species" Veronica buxifolia.

Fig. 2.—Juvenile Coprosma Baueri.
Showing early prostrate shoots and later erect ones.

treatment are *Olearia Haastii* Hook. f. and *O. oleifolia* T. Kirk (p. 290), *Ranunculus Sinclairii* Hook. f. and *R. gracilipes* Hook. f. (p. 18), and *Poa seticulmis* Petrie and *P. pusilla* Berggr. (p. 905).

6. *Veronica buxifolia* Benth., as originally defined, probably referred to a quite definite set of individuals Even by Cheeseman (pp. 522, 523) the species is spoken of as a "plant," and not as a varying series of forms. Further, the species is defined as "erect," and but one variety is allowed. In point of fact, however, the "species" includes three distinct growth-forms, at any rate, two of which, *the prostrate*, and *the low, erect, sparingly branched*, are shown in Plate II, fig. 1. The var. *odora* T. Kirk (*patens* Cheesem.) is of *the ball-like* growth-form. *In this example, then, a taxonomic species includes plants belonging to at least three absolutely distinct biological categories.* And, in addition, it is highly probable that a dozen or more distinct true-breeding entities might easily be separated from the heterogeneous mass of individuals known as *V. buxifolia*.

7. Many varieties are of a quite different physiological value to others. Some, as in cases 1, 2, and 6, reproduce themselves true from seed. This I have definitely proved in a number of instances; *they are, in fact, true elementary species.* Others, again, are merely *environmental* (unfixed epharmonic)* *forms*, such as are dealt with further on, of which notable examples are the var. *prostrata*† Hook. f. of *Leptospermum scoparium* Forst. (p. 160), the var. *rhombifolius*‡ Hook. f. of *Ranunculus pinguis* Hook. f. (p. 12), and the var. *pauperatus*§ T. Kirk of *Rubus cissoides* A. Cunn. (p. 125). Finally, other varieties represent a series of forms regarding the stability of which nothing is known, but which are supposed, without any sufficient reason, to be unstable.

Without going into further details, it is evident that the species of New Zealand taxonomists are rather the creation of man than of Nature. In saying this I am not hypercritical. The main object of a flora is to enable a plant to be readily identified, and this, from the very nature of the case, demands a more or less artificial classification. Where such precise and copious information as to variation is given as in Cheeseman's most careful and exact work there need be no mistake, and the worker in the field knows exactly what he may expect. But, as a rule, writers on evolution have quite neglected to distinguish between *taxonomic* and *physiological* species, which latter alone are their concern.‖

Although breeding-experiments can alone decide as to fixity of form, ecology should tell something. If a certain set of individuals remain unchanged over wide areas, so far as their specific marks go, and under varying conditions, it may be assumed with tolerable confidence that they reproduce their like, and are therefore species, elementary or Linnean, as

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* Such forms are called by Massart "accomodative," in contradistinction to "adaptive"—*i.e.*, specific and hereditary. Regarding taxonomic varieties, the same author writes, "Malheureusement on ne peut pas toujours se fier aux travaux de systématique pour distinguer les accomodations des variations proprement dites," and he cites the example of *Polygonum amphibium*, with its varieties *natans*, *terrestre*, and *maritimum*, all of which are simply accomodative states. (1910, pp. 9, 10.)

† See Cockayne, 1909, p. 16.

‡ See Cockayne, 1909A, p. 201.

§ See Cockayne, 1901, pp. 293, 294.

‖ O. F. Cook's remarks are worthy of consideration (1907, pp. 362, 363): "The difficulty of defining the term 'species' has arisen mostly from the fact that the phenomenon is a physiological one, whereas the general supposition has been that it is morphological. . . . For evolutionary purposes a species is a group of interbreeding organisms; nothing more is required, nothing less will suffice."

the case may be. And perhaps it is allowable to go further, and say that if several allied plants grow in close proximity in sufficient numbers, and preserve their distinguishing characters, they are probably distinct, and would come true from seed. A case of this latter class is to be seen at the lower gorge of the River Waimakariri, Canterbury Plain, where the vars. *microphylla* Hook. f. and *prostrata* T. Kirk of *Sophora tetraptera* J. Mill. grow side by side, and in this case I have proved experimentally that both varieties come true from seed. So, too, with certain forms of *Acaena Sanguisorbae* Vahl. growing on subalpine fell-fields.

There is no need to multiply instances such as the above; suffice it to say that both from experiment and ecological observations I am satisfied that *elementary species are very numerous in the New Zealand flora*, especially in certain genera—*e.g.*, *Calamagrostis*, *Danthonia*, *Poa*, *Festuca*, *Scirpus*, *Uncinia*, *Carex*, *Luzula*, *? Phormium*, *Ranunculus*, *Cardamine*, *Pittosporum*, *Rubus*, *Acaena*, *Carmichaelia*, *Oxalis*, *Coriaria*, *Aristotelia*, *Pimelea*, *Epilobium*, *Leptospermum*, *Anisotome*, *Aciphylla*, *Gaultheria*, *Dracophyllum*, *Gentiana*, *Myosotis*, *Veronica*, *Coprosma*, *Celmisia*, *Cotula*, *Craspedia*, and *Senecio*. On the other hand, many species vary to a slight degree only, and are to be recognized at a glance.

III. Variation.

Apart from constant hereditary distinctions, there are "the individual differences," as Darwin called them (1899, p. 31), or "fluctuating variations," as they are now frequently designated. These are supposed to depend upon a reaction of the organism to a change of environment. Klebs (1910, p. 235) distinguishes two kinds, the one "caused by different external conditions during the production either of sexual cells or vegetative primordia," and the other "is the result of varying external conditions during the development of the embryo into an adult plant." The two sets of influences cannot as yet be sharply differentiated. The following case illustrates this difficulty.

Olearia semidentata Dcne. is a moderate-sized xerophytic shrub, which is confined to the moors of the Chatham Islands, where both the climatic and edaphic conditions appear to be of great constancy (Cockayne, 1902, p. 288). The leaves vary on different individuals in size, shape, toothing, and tomentum, and plants grow side by side which, so far as general appearance goes, might easily be taken for distinct species. Probably here the variations are germinal, but at the same time each plant has its own rooting-place* and its individual physiological character, so it cannot be denied but that each plant is subjected to slightly different stimuli to those experienced by any other.

A most important question is the heredity in fluctuating variations and the degree to which they can be accumulated. Darwin (1899, pp. 31, 32) considered them all-important. "These individual differences," he writes, "are of the highest importance for us, for they are often inherited, as must be familiar to every one; and they thus afford materials for natural selection to act on and accumulate in the same manner as man

* The importance of the rooting-places of individuals is generally neglected by plant-ecologists who define the conditions of the *habitat* as a whole, whereas species growing side by side may be subjected to quite different influences, as in the case of shallow- and deep-rooting species, erect and prostrate, and so on.

accumulates in any given direction individual differences in his domesticated productions." And further on (p. 38), "Hence I look on individual differences . . . as of the highest importance for us, as being the first steps towards such slight varieties as are barely thought worth recording in works on natural history." De Vries and his followers, on the other hand, deny that a fluctuating character can be accumulated indefinitely, and affirm that, "Selection according to a constant standard reaches its results in a few generations. The experience of Van Mons and other breeders of apples shows how soon the limit of size and lusciousness may be attained. . . . Improvements of flowers in size and colour are usually easy and rapid in the beginning, but an impassable limit is soon reached" (De Vries, 1904, pp. 806, 807). Further (p. 18), "Fluctuations always oscillate round an average, and if removed from this for some time they show a tendency to return to it. This tendency, called 'retrogression,' has never been observed to fail as it should in order to free the new strain from the links with the average." Again, "Fluctuations are not observed to produce anything quite new, and evolution, of course, is not restricted to the increase of the already existing peculiarities, but depends upon the continuous addition of new characters to the stock." The opinion of Klebs cannot be overlooked in this matter. This famous investigator has shown in his remarkable experiments (Klebs, 1903) that variations can be artificially induced which are far beyond the limits of fluctuating variability and considerably greater than any mutations hitherto recorded.

Ecological observations can say little on a debatable topic like this, where long-conducted experiments are alone of weight. Some observations regarding vegetables which have escaped from cultivation in New Zealand are not without interest, as showing reversion to the wild state. The radish (*Rhaphanus sativus* L.) is abundantly naturalized near Wellington, but the roots are no longer swollen to any extent. The parsnip (*Peucedanum sativum* Benth. & Hook.), probably the celebrated "Student," which is supposed by writers on evolution to be a fixed race,* came up year by year in a neglected part of my garden, but in a much deteriorated form.† So, too, with "improved" pansies, primroses, and polyanthuses‡ in my garden, and with *Eschscholtzia californica* as naturalized near Cromwell, Central Otago.

In many cases fluctuating variations are very small, and appear to be neither an advantage nor the contrary to their possessor. In other cases there are variations of much greater magnitude, which ecological observations, as shown further on, prove to be distinctly dependent upon external stimuli bringing about a response within the plant which is manifested by a visible morphological or an invisible physiological change.

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* Romanes (1895, p. 125) writes, "That is to say, it has come true to seed for the last forty years." Romanes mentions this case as an example in support of the heredity of an acquired character, but Darwin (1905, p. 229) mentions it as a case of "methodical selection."

† With a species such as this it really must be nearly impossible to judge under European conditions how far a supposed "wild" plant may be really wild and not the descendant of a cultivated form.

‡ The leaf-like calyx of the primroses, &c., known as "Jack-in-the-green" is a remarkably persistent character.

IV. Mutations.*

There seems to be no doubt but that De Vriesian mutations arise from time to time. That such afford a better material for preservation by natural selection than do small fluctuating variations is obvious. Unfortunately, the number of cases of veritable mutants is small, while most have originated in cultivation. This last fact discounts the value of the mutation theory in the opinion of many.† My own feeling, as an amateur gardener of many years' standing, and as one who has cultivated with his own hands several thousand species of both wild and garden plants in an antipodean garden far from the home of most, is that ordinary cultivation, without manure, has little effect in producing variations of moment. In my garden, plants reproduced themselves from seed freely and came to maturity, but beyond a number of daffodils and some, probably hybrid, dwarf phloxes (*Phlox subulata* L.) I remember nothing "new."

In estimating the origin of species by mutation, nothing but experiment can prove the heredity of the new character. All that ecology can do is to note striking varieties, their frequency, their environment, the position of the individual possessing such variations with regard to normal individuals, and so on.

The following examples of what may be full or partial mutations in the New Zealand flora, indigenous and introduced, may be of interest :—

1. The white form of *Myosotidium nobile* Hook.

The species is confined to the Chatham Islands, where it grows on or near the sea-shore. In the normal form the central half of the corolla is bright blue, which fades to purple, and the edges are more or less white. Mrs. Chudleigh, of Wharekauri, some years ago discovered *one* plant with white flowers growing wild in the north of the main island, and although she is an excellent observer, and *Myosotidium* has been carefully noted in its habitat by Mr. Cox and others, no more white-flowered forms have been observed. The plant in question is now fairly common in cultivation, and, I understand, comes true from seed. So, too, does the normal blue form.‡

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* Something not very different to the mutation theory was propounded by J. B. Armstrong, formerly of the Christchurch Botanical Garden, in a paper dealing with the New Zealand species of *Veronica* in 1881, in these words: "I have been enabled to observe numerous garden-seedlings of many of the forms, and they almost invariably resemble their parents. Sometimes, however, sports appear, and when this happens there seems to be a strong tendency on the part of the sport to reproduce itself, and it appears to me that it is just in this manner that the greater number of our native forms have been produced. At some very distant date there were probably only two or three (perhaps only one) species existing within the limits of the colony; but, on account of the extreme local variations of climate and varied geological formation of the surface, certain variations occurred, and a sport so produced, being self-fertile, and having within itself all the elements required for reproduction, naturally reproduced its like until another such sport occurred, and thus the forms gradually became differentiated from the type, and by a long series of such sports one large family of *Veronicas* has been formed." Then he goes on to show how similar mutations have taken places amongst species of other lands, and considers that the intermediates have been eradicated "by man or the larger animals, leaving only in most cases the more widely differentiated forms." But in New Zealand man has done little, and very many intermediate forms have been preserved.

† Klebs, however, writes (1910, p. 241), "Even if it is demonstrated that he was simply dealing with the splitting-up of a hybrid, the facts adduced in no sense lose their very great value."

‡ Raising from seed is, in fact, the only satisfactory method of propagating both the type and the white-flowered form.

2. The white variety of *Clianthus puniceus* Banks & Sol.

The type has scarlet flowers. It is now very scarce as a wild plant, but grew originally on or near sea-cliffs from the East Cape district northwards, and inland at Lake Waikaremoana. The type is a most common garden-plant; it is propagated from seeds, and comes true. According to Cheeseman (1907, p. 443), from information supplied by Mr. H. Hill, the flowers of East Cape plants vary considerably in colour, size, shape, and relative proportions of the petals. At Waikaremoana the flowers are comparatively small and reddish-purple. At Tolaga and Tokomaru they are large, and the standard very broad, with a whitish stripe on each side near the base.

The white form is white throughout. It is propagated from seed, and, according to Mr. T. W. Adams, comes true.* It is very common in cultivation. As for its origin, according to Cheeseman, "a white-flowered variety is stated by the Maoris to grow on the Tiniroto cliffs." This may or may not be the source of the garden form. Possibly *C. puniceus* consists of several elementary species.

3. *Geranium Traversii* Hook. f. var. *elegans* Cockayne (Geraniac.).

The normal colour of the flowers of *G. Traversii* is white. It grows on coastal cliffs of the Chatham Islands. The flowers of var. *elegans* are pink in colour, and rather larger. It comes "true" from seed. According to Captain Dorrien Smith, it is found occasionally on Chatham Island, but I only know it as a garden-plant.

4. *Phormium tenax* Forst., form with purplish leaves (Liliac.).

The origin of this striking plant is not known. It is very common in New Zealand gardens. It appears to come very nearly, or perhaps absolutely, true from seed, and the young plants have much more brilliantly coloured leaves than the adult.

P. tenax was commonly cultivated by the Maoris, who recognized by name many distinct-looking forms.† Some of these appear to reproduce themselves more or less true, while others are probably of hybrid origin.

5. *Phormium Cookianum* Le Jolis, form with bracts in part instead of flowers (Liliac.). (See Williams, 1904, p. 333, and pl. 25.)

The plant in question was discovered by the Right Rev. Bishop Williams growing a little above high-water mark at Blackhead. It was then in seed, and the capsules were accompanied by numerous persistent bracts. A few of the seeds were sown. One of the young plants produced an inflorescence similar to that of the parent in 1900 and 1901, but in 1902 the four scapes produced flowers and seeds in the usual way, but these in the course of the summer "began to be clothed with leaves" in their upper portions.

6. Various crimson- and pink-flowered forms of *Leptospermum scoparium* Forst. (Myrtac.).

At least six individuals of *Leptospermum scoparium* bearing crimson or deep-pink flowers without a trace of white have been found wild in various

* Mr. Cheeseman informs me that he also has raised the white form from seed, and that none of the plants produced flowers other than white.

† Fifty-seven names are given in "*Phormium tenax* as a Fibrous Plant" (Wellington, 1872), but it is now known that many of them are synonyms. There are extensive collections on some of the Government experimental farms, where their behaviour as to constancy, hybridization, &c., is being studied.

parts of New Zealand. The two best known bear the garden names of *L. Chapmanii** and *L. Nicholsii** respectively. Seedlings in abundance have been raised from the latter by Messrs. Nairn and Son, Christchurch, in their nursery, and every opportunity was kindly afforded me of studying their form, &c. (see Cockayne, 1907A). The colour of the original plant is repeated more or less in the seedlings, but it varies a good deal, and some flowers are white. Dark-coloured leaves, a parental character, accompany the darker flowers.

In a case recorded by Cheeseman the plant was reported by its finder, Mr. R. J. Gilberd, to come true to colour (Cheeseman, 1908, p. 275).

It is obvious that these crimson forms only appear occasionally, for they are too striking in contrast with the familiar white blossoms to be overlooked by even a casual observer. Further, the change of colour is deep-seated in the plant, since the leaves are also affected. In *L. Nicholsii* Hort., too, the plant is of a weeping habit, as opposed to the normal erect stature. Finally, it must be noted that the semi-mutants grew in widely separated localities, some in the South and others in the North Island.

7. Double white form of *Leptospermum scoparium* Forst. (Myrtac.).

This was found growing wild on pumice soil in the Hot Lakes district by Mr. E. Philipps Turner. The doubling is very complete, and, so far as I could judge from much-damaged specimens, resulted from petalody of the stamens. Probably it is unable to produce seed. This case is of further interest because double flowers, as De Vries has pointed out (1905, p. 489), are exceedingly rare in the wild state, though so common in cultivation. Only *one* individual was noted. The mutation was evidently quite spontaneous, and cannot be attributed to any sudden change of soil-conditions.

Leptospermum scoparium is a most variable plant. Doubtless some of the forms are good elementary species. The form with pinkish flowers and hairy leaves, &c., of northern Auckland, which occurs over wide areas side by side with other forms from which it can be recognized at a glance, is a case in point.

8. *Olearia semidentata* Dcne., form with white florets.

The type has brilliant purple flower-heads. The white form was discovered growing wild by Captain A. A. Dorrien Smith. It is now in cultivation in the garden at Tresco Abbey, Scilly.

A similar case is var. *Dendyi* Cockayne of *Olearia chathamica* T. Kirk, found on Pitt Island by Dr. A. Dendy, F.R.S., and which has purple florets and yellower denser tomentum on the under-surface of the leaf than the type, the florets of which, moreover, are white fading to purplish.

9. *Metrosideros lucida* Menzies, form with white flowers.

The type has crimson flowers. The white-flowered form has been found in two places, one plant which I have seen growing near the head of the Otira Gorge, Westland, and the other lower down the valley.†

10. *Metrosideros tomentosa* A. Rich., form with yellow flowers.

Mr. H. Carse (Cheeseman, 1906, p. 1137) discovered one specimen with yellow flowers, those of the type being dark crimson, at Rangaunu Harbour, northern Auckland.

* Because I use these garden names it must not be concluded that I consider the plants of the same biological class as Linnean species, or even elementary species.

† I am indebted to Mr. J. O'Malley, of Otira, for calling my attention to the latter plant.

11. *Rubus Barkeri* Cockayne.

This is a presumably non-flowering species (see Cockayne, 1910, p. 325); at any rate, cuttings from an adult plant growing luxuriantly and under most varied conditions for a period of thirteen years have never flowered. Be this as it may, the plant in question, although closely related to *R. parvus* Buchanan, differs from that species in its trifoliate leaves with lanceolate* leaflets and not simple linear leaves, its serrate and not dentate leaf-margins, its different autumnal colouring and its greater size in all parts (see fig. 1).

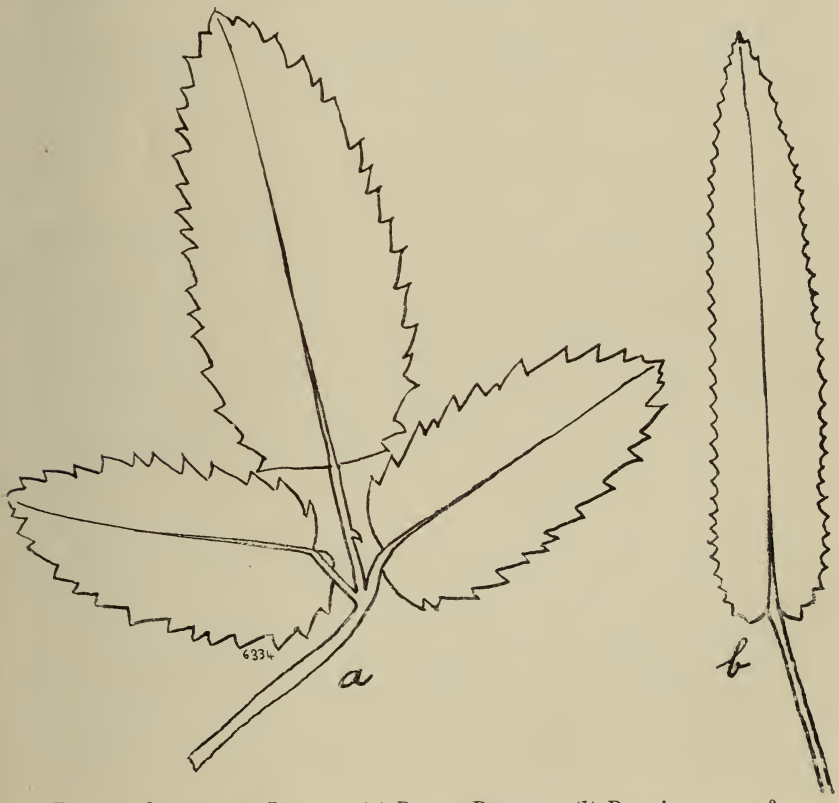

Fig. 1.—Outline of Leaf of (*a*) Rubus Barkeri, (*b*) R. parvus. × ⅔.

Only one plant was originally noted. Recently I have seen abundance of *Rubus parvus* in various localities in Westland and under different conditions, but it is remarkably constant in characters, and *presented no transitions* towards *R. Barkeri*. I know well that my action in "creating" a taxonomic species in this case is open to adverse criticism, especially as I believe that the original wild plant may be the only one in existence; but if a species can originate by mutation there must be a time when there is only *one* individual, and if so, and its characteristic marks are of "specific" importance, it is just as much a "species" as if there were thousands of similar individuals.

* So defined in original description, but leaflets in fig. 1 are broader.

12. *Veronica Benthami* Hook. f., form with white flowers.

V. Benthami is a shrub of straggling habit endemic in the Auckland Islands. The flowers are normally of a brilliant blue, a most unusual colour amongst New Zealand plants. One or two individuals with white flowers were noted by me in 1907. Also, another plant had the flowers almost carmine when just opening, but fading to a paler colour on the outer parts of the corolla when fully expanded (Cockayne, 1909, p. 203).

13. Occurrence of variegation, &c.

There are three forms of variegated *Coprosma Baueri* Endl. in cultivation of whose origin I know nothing. A variegated form of *Griselinia littoralis* Raoul was discovered a number of years ago by the late Mr. Purdie in the vicinity of Dunedin. The late Mr. H. J. Matthews found, also in the neighbourhood of Dunedin, a form of *Fuchsia excorticata* L. f. with very dark-coloured leaves, quite different from the normal. One individual of *Cordyline australis* Hook. f. with variegated leaves was found many years ago in a batch of seedlings raised at Duncan's nursery, Christchurch. It appears to come true from seed. Variegated forms of *Veronica salicifolia* Forst. have appeared on several occasions in cultivation. There are variegated forms of *Pittosporum tenuifolium* Banks & Sol. and *P. eugenioides* A. Cunn., but their origin is unknown. A form of *Coprosma robusta* Raoul with yellow and not the typical red-orange drupes was found by me near Kaipara Harbour, Auckland. There are a number of variegated forms of *Phormium tenax* Forst. and *P. Cookianum* Le Jolis in cultivation, which come more or less true from seed, but a variegated plant of the latter species found wild by me on Mount Sherwood, Marlborough, upon being brought into cultivation reverted to the type.

14. *Tetragonia expansa* Murr.

This case is cited by De Vries (1901, p. 469). There are two forms, one with brownish and the other with green flowers; both came true. The wild plant in New Zealand has yellow flowers.

15. *Pittosporum tenuifolium* Banks & Sol., form with yellow flowers.

In New Zealand, so far as is known, the petals are invariably dark-purple, almost black. But, according to H. M. Hall (1910, pp. 7, 8), two shrubs growing in a row of the normal-coloured plant in California produced *yellow* flowers. Should this be at all common in New Zealand it could hardly have escaped notice.

16. Introduced plants.

Some remarkable more or less hereditary variations have come about in the broom (*Cytisus scoparius* Link.), gorse (*Ulex europaeus* L.), and tree-lupin (*Lupinus arboreus* Sims). In the first two named species there are colour-changes from the normal yellow to white, differences in size and shape of flower, and, in the gorse, variation in time of blooming.

Lupinus arboreus Sims, normally yellow, and varying but little in its native land, on the dunes near New Brighton, Canterbury, has undergone many remarkable changes in the colour of its flowers. There is, *e.g.*, a pure-white, yellows of various tints, and a great variety of purples combined, or not, with whites and yellows. These abnormally coloured plants occur in patches here and there as a general rule, and appear to get more abundant year by year. In the North Island I have neither noticed nor heard of such variations, nor yet in Central Otago.

Red clover (*Trifolium pratense* L.) and cowgrass (the var. *perenne*) vary to an astonishing extent in a small patch, chiefly self-sown, in my garden. Many of the forms are most distinct, and the new characters are diverse, affecting colour of flowers, stems, and foliage, form of inflorescence, degree and kind of hairiness, general habit, &c. Here pure culture-methods and Mendelian procedure would be needed to come to any reliable conclusions as to variants such as these.

Holcus lanatus L. and *Dactylis glomerata* L., I am informed, vary at times beyond their ordinary fluctuating capacity.

Capsella Bursa-pastoris Medic., a very variable species in its natural habitat, and which has already given rise to certain mutants, varies to an astonishing degree in New Zealand, especially in highly manured ground. A careful study of such variation is certainly demanded.

V. Epharmony.

1. *General.*

It is when we come to epharmonic adaptations that ecology presents its most important contribution to the evolution question.

In attempting to explain the origin of epharmonic adaptations it is evident that, as in the case of *all* explanations of evolutionary phenomena, no *absolute* proof can be given without experiment, and, where such is wanting, it seems reasonable that the most probable explanation should be accepted for the time being, notwithstanding that other though less probable explanations would fit the case. Generally in polemical discussions on matters of evolution natural selection is assumed to be a *vera causa* which needs no demonstration, and if any other reason is put forward, however likely it may appear, it is considered of no moment, unless it can be proved not merely to the hilt, but to the objector's satisfaction.

Now, I am of opinion that in the hereditary epharmonic variations cited below there is a much greater likelihood of their having been brought about by the direct action of the various ecological factors than by the continuous accumulative selection of fluctuating varieties, and in making this statement I am merely echoing the opinion regarding analogous phenomena of Romanes (1895, pp. 122–32), Warming (1909, pp. 370–73), MacDougal (1911, p. 57), Henslow (1895, 1908), Costantin (1898), (Scott-Elliott, 1910), and many other writers on evolution.

With the much-disputed Lamarckian factors *use* and *disuse*, which are so frequently the *only* parts of the doctrine dealt with by the zoological opponents of modified Lamarckism, I have nothing to do. How far evolutionary methods correspond in the plant and animal kingdoms no one can say, but it does not seem unreasonable to imagine that they may have been in many respects different.* At any rate, this paper is concerned only with the botanical side of evolution.

2. *Fixity of Species—Plasticity.*

Nothing has been brought out more clearly by ecological studies in New Zealand than the extreme "plasticity" of many species and structures, and their rapid response to a change of environment. *This is so*

* Leavitt (1907, p. 237) writes, "In no case is it safe to reason deductively from one kingdom to the other. In the factors affecting their evolution, plants and animals differ vastly.

great in numerous instances that the idea of "normal" loses its meaning. Take the following examples :—

(*a.*) *Leptospermum scoparium* Forst. (Myrtac.) may be *a moderate-sized tree, a tall shrub, a dwarf plant* 2–8 cm. tall which flowers and ripens seed, and *an absolutely prostrate plant* which forms a dense covering to the ground and puts forth adventitious roots, although the erect forms are exceedingly difficult to artificially strike as cuttings.

(*b.*) Certain shrubs are of *the xerophytic divaricating growth-form* when growing in the open, but of *a comparatively loose, leafy, and mesophytic habit* when growing in the shade and shelter of the forest—*e.g.*, *Pittosporum divaricatum** Cockayne, *Corokia Cotoneaster* Raoul, *Aristotelia fruticosa*† Hook. f., &c. In such a case, were the shade form alone in existence (see Plate VII, fig. 1), there is no botanist but would consider it fixed and normal, and yet it is the sun and wind form rather that is so considered.

(*c.*) *Fuchsia Colensoi* Hook. f. (Onagrac.) is *a twiggy shrub* in the open, but in the forest it is frequently *a scrambling liane.*

(*d.*) *Hymenophyllum multifidum* Sw. (Filic.) when occupying wet rocks in the Auckland Islands has its fronds closely *curled up*, but when growing in the forest interior of the same group they are *quite flat.* That the curled fronds are not fixed I have shown by means of moist-air culture (1904, pp. 266, 267). Suppose that *H. multifidum* was only found on a wind-swept treeless island, such as Macquarie Island, no one would question the curled frond being normal and fixed.

(*e.*) *Myoporum laetum* Forst. f. (Myoporac.) is nearly always *a small round-headed coastal tree* having a distinct erect trunk, but on Moko Hinou Island *it is altogether prostrate*, and its branches far-spreading, cord-like, and twiggy. Were it not that I have seen intermediate forms on some parts of the North Island coast I could hardly believe that the Moko Hinou plant was not a stable form.

(*f.*) *Myrtus pedunculata* Hook. f. (Myrtac.) is generally either *a small tree* or *a twiggy erect shrub*,‡ but at an altitude of some 1,200 m. in the *Nothofagus* forest of the volcanic plateau, North Island, *it is frequently quite prostrate and rooting. Styphelia fasciculata* Diels (Epacrid.), although nearly always an erect shrub as a forest-plant, behaves exactly as the last-named in the same station. On dunes it is also frequently prostrate.

(*g.*) *Dracophyllum politum* Cockayne (Epacrid.) when growing on the mountains of Stewart Island is *a turf-making shrub, a low spreading shrub* with stout horizontal branches, or *a massive ball-like cushion plant*, according to circumstances. So different are these various forms that I can hardly yet believe them to be merely environmental unfixed forms of one another§ and that my observation is not faulty.

(*h.*) *Gleichenia dicarpa* R. Br. and *G. circinata* Sw. (Filic.) differ specifically in the former having the margins of the segments of the pinnae incurved so as to be pouch-shaped, whereas those of the latter are virtually flat. But the same individual of the var. *hecistophylla* Hook. f. will possess

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* This plant has been merged with *P. rigidum* Hook. f. A diagnosis has not yet been published, owing to lack of sufficient material, but it is necessary here to use a definite name, since *P. rigidum* and *P. divaricatum* are certainly distinct entities. (See Plate I.)

† For further details, see Cockayne, 1901, pp. 265–67, and Diels, 1906, pp. 66–69.

‡ It is possible that the tree and shrub are different species, but I hardly think so, though I have not seen intermediates.

§ See Cockayne, 1909, p. 16, and photo No. 13, facing p. 17.

some *pinnae with pouches* and *others quite flat*, in accordance with the degree of illumination to which they are exposed. In fact, here *the specific distinction does not hold*—it is merely epharmonic—and the latest name must be abandoned ; nor can the two "species" be maintained even as "varieties."

(*i.*) *Discaria toumatou* Raoul (Rhamnac.) when growing in positions subject to the attacks of rabbits may form *low green cushions* made up of leafy spineless shoots. "Normally" it is *a stiff branching shrub* furnished with abundant spines.

Many more examples could be cited, but the above show clearly enough how unstable species may be, even when growing under natural conditions. When experimental methods are brought into play the effects from plasticity become still more striking. For example, spine-production may be suppressed in *Discaria toumatou ;* true leaves may be produced in the whipcord veronicas and species of *Carmichaelia* (Legum.) ; rolled leaves made flat,* and *vice versa ;* cushion plants opened out widely. Undoubtedly a series of experiments such as those of Klebs (1903) would yield results equally surprising.

It can be seen from the above that this uncertainty as to "normal" form opens up room for great doubt in all discussions regarding the origin of *permanent* adaptations, for *it may quite well be asserted that absolute fixity does not exist.* It seems to me all that can be done is to consider as "normal" those forms which predominate and represent the general growth-form of the bulk of the individuals ; but *assuredly in no few cases there is no normal form at all.*

3. *Response to Ecological Factors.*

Warming has summed up the state of knowledge on this head up to the date of publication of his admirable "Oecology of Plants" (Warming, 1909, pp. 16–81), so that only a few local examples are necessary here. First of all, it must be emphatically pointed out that it is virtually impossible in the field, where so many ecological factors are concerned, to say which is the predisposing cause of the internal response of the plant. Generally more than one factor will be concerned.

(a.) *Soil.*

Excess of salt leads to succulence, as in certain salt-meadow species which become less succulent as members of non-halophytic formations. The introduced *Silene anglica* L. develops more succulent leaves when growing near the sea than inland. Miss Cross examined the anatomy of certain salt-meadow plants and those of the same species grown in ordinary soil in a greenhouse. Her figures show considerable differences in thickness of leaves, but other factors besides want of salt doubtless affected the result (1910, pp. 569–71).

The soil near hot springs containing excess of sulphur, &c., inhibits the erect shrub form of *Leptospermum ericoides* A. Rich., which then occurs only in the prostrate form.

Lack of nutritive salts in sand-plains near the mouth of the River Rangitikei and elsewhere changes the leaf-form of *Selliera radicans* Cav. (Gooden). This is in accordance with the much more carefully conducted observations

* In the case of *Olearia cymbifolia* Hook. f. the much revolute, boat-shaped leave become flat with moist-air culture, and what was considered an important specifi character, distinguishing the "species" from *O. nummularifolia* Hook. f., vanishes.

of Massart, which are supported by soil-analyses (1910, pp. 156–65). The prostrate habit of certain shrubs of dune-hollows in the north of Auckland may, in part, be similarly explained.

Acid peat soils favour the cushion and other xeromorphic growth-forms, though mesophytic forms may also occur.*

Phyllachne clavigera F. Muell. (Stylid.), and doubtless its allies of similar cushion-form, can be made of much looser growth by moist-air culture (Cockayne 1909A, p. 201).

The shoots of *Cotula Haastii* T. Kirk (Compos.), one part of a plant rooted in deep soil, and another part on rotten rock or shallow soil, exhibit certain striking differences. These are chiefly in degree of intensity of characters. The portion in shallow soil has smaller leaves, stiffer stems, more glands, and the leaf-segments closer. The leaves are of a darker green, and are marked with brown on the lower half, whereas there is no trace of brown on the deep-rooting portion. A dune form of *Acaena microphylla* Hook. f. behaves similarly in my garden, the leaves of non-rooting shoots being much smaller than those of rooted shoots and broadly margined with brown, the " normal " leaves being lighter green and faintly brown at the apices of the teeth at most. This presence or absence of a dark colouring-matter would appear of small importance were it not that dark-coloured leaves are a rather frequent characteristic of New Zealand plants.

Plants exposed to drifting sand may develop an upward growth. Thus, *Poa caespitosa* Forst. f., although a steppe tussock-grass, when growing on drifting sand in Central Otago gets more or less a sand-binding form. So, too, with *Phormium tenax* Forst. and *Arundo conspicua* Forst. f. on coastal dunes, though both are commonly swamp-plants.

Scirpus frondosus Banks & Sol., a sand-binding plant of the most extreme type, is not only endemic, but belongs to an endemic subgenus (*Desmoschoenus*). Not only has this plant attained its growth-form in an isolated dune-area, but, as Mr. R. B. Oliver suggests in a letter to me, possibly in actual competition with the Australian *Spinifex hirsutus* Labill.

At one place in Puhipuhi Valley, Seaward Kaikoura Mountains, nearly all the species, both indigenous and introduced, growing on cold, wet, limestone soil exhibit marked variegation, but beyond this chaphic influence they are of the normal green.

Highly manured soil, as is well known in cultivation, acts powerfully upon plant-form. In nature the same occurs. Plants of *Sicyos australis* Endl. growing on ground manured by *Puffinus sphenurus* in the Kermadec Islands frequently produce male flowers in which " the petals turn green, and assume more or less the shape and character of foliage leaves " (Oliver, R. B., 1910, p. 132). Certain species appear confined to soil of the above character—*e.g.*, *Senecio antipodus* T. Kirk, of Antipodes Island and *Cotula Featherstonii* F. Muell., of Chatham Island.

(b.) *Light.*

The bright light of dunes probably leads to the red- or orange-coloured stems of the rush-like *Leptocarpus simplex* A. Rich (Restiac.), which are green in the shade, and as salt-swamp plants not nearly so brilliantly coloured. It is a moot point how far the reddish, yellowish, or brownish hue of certain true dune-plants may be considered fixed and hereditary

* See on this head Burns, 1911, pp. 121, 124. Xerophytes are confined to certain zones in the bogs studied, the largest bog-areas being hydrophytic or mesophytic.

(*e.g.*, *Scirpus frondosus* Banks & Sol., *Coprosma acerosa* A. Cunn., *Gunnera arenaria* Cheesem., *Euphorbia glauca* Forst. f.).

An interesting case is that of *Lycopodium ramulosum* T. Kirk, a plant forming extensive patches on moors in the west of the South Island and Stewart Island, the sporophylls of which are absent or scantily produced in shade plants, but extremely abundant in those growing in bright light.

Many young trees in the forest assume a special form with a slender main stem and few branches, which are confined to its upper portion. Similarly, the xerophytic fern *Pteridium esculentum* Cockayne becomes in a dim light a scrambling liane. An example observed by Mr. H. Carse and myself was growing amongst tall, slender *Leptospermum scoparium* on Reef Point, north-west Auckland. Some of the fronds were more than 3 m. in length. Pinnae were absent until the brighter light was gained. The final portion of the rhachis was green and succulent, and the distance between the pinnae 46 cm. These latter were still coiled up and quite rudimentary, although the largest was 25 cm. long. The rhachis was twisted—*i.e.*, it showed a tendency to twine.

Shade—and here probably comes in moisture in the air—increases the size of leaves, changes certain xerophytes into mesophytes: *e.g.*, species of *Carmichaelia*, *Discaria toumatou*. *Podocarpus nivalis* Hook., as may be plainly seen from Plate IV, responds markedly to changes in illumination, the shade form resembling *P. totara* much more than the species which it really is. The specimens were collected within a few feet of one another.

The lie of the leaf is regulated by the light. *Olearia insignis* Hook. f., a shrub of dry rocks in Marlborough, arches its branches upwards to a surprising degree, thus bringing its leaf rosettes into a suitable position with regard to the light. This habit persists in plants raised from seed and grown on flat ground.

(c.) *Wind.*

Wind is a most important factor in New Zealand. First comes the "wind-shearing" action, which is in part a physiological process; it is well marked in trees and shrubs of exposed positions, and may be frequently seen in *Podocarpus totara* D. Don., *Leptospermum scoparium* Forst., and many other plants. The prostrate habit is encouraged by wind; but here other factors may enter in, as cold and acid soil. *Coprosma foetidissima* Forst. is usually a tall forest-shrub, but when a member of the tussock-moor association of the Auckland Islands (Cockayne, 1909A, pp. 200, 201, and 219) it is prostrate and twiggy. The prostrate form of *Leptospermum scoparium* on the subalpine moors of Stewart Island is another and remarkable example. Well-developed prostrate trunks are to be seen in *Metrosideros lucida* Menz. (Myrtac.) in the Auckland Islands, Stewart Island, and the Southern Alps, and in *Olearia ilicifolia* Hook. f. (Compos.) in some subalpine forests of the South Island. Reduction in size of leaves must often be attributed to wind-action.

(d.) *Water.*

Plants of still or slowly running water are subjected to a fairly constant environment.* *Cotula coronopifolia* L., as a *land-plant*, is a herb with branched, prostrate, more or less rooting stems, the branches of which are erect or semi-erect; the internodes are short; the leaves are rather fleshy, more or less lanceolate in outline, and pinnatifid, lobed, toothed, or sometimes entire; the roots are, at most, of a moderate length. As a

* Of course, the position of the plant with regard to the surface, the nature of the substratum, and other factors exercise a considerable influence.

water-plant, the stem is straight, unbranched, and perhaps 40 cm. long; the internodes are long; the leaves linear and entire, and the roots numerous and 30–40 cm. long; when the shoot rises above the water-surface it branches, and the leaves are much as in the land-plant.

Not only the leaves but also the inflorescence differ greatly in size in the land and water forms of the introduced *Radicula Nasturtium-aquaticum* Brit. & Rend.

Specially moist air causes the production of aereal roots on the stems of certain whipcord veronicas.

Schefflera digitata Forst. (Araliac.), a low forest tree or shrub, when growing in certain damp gullies of northern Auckland produces sometimes leaves much more deeply cut than the normal.

The moist-gully form and the dry- or acid-ground form of *Blechnum capense* Schlcht. (Filic.) are so distinct in appearance that many might consider them distinct species.

(e.) *Altitude.*

Altitude is a complex combination of factors which sometimes produces striking differences in the same species, according to the height at which the individuals grow.

A very common feature is diminution of stature with increase of altitude, though this is not so with all species. The trees *Dacrydium cupressinum* Sol., *Weinmannia racemosa* Linn. f., and *Griselinia littoralis* Raoul are much reduced in size when forming a part of the mountain-scrub of Stewart Island, the two latter eventually becoming small shrubs.

On the other hand, if the lowlands can offer an equivalent environment to that of the mountains—though, of course, it can never be actually identical—alpine plants may occur at sea-level, their forms differing not at all from those at an altitude of 600 m., 900 m., or considerably higher. The lowland moor of Stewart Island contains various alpine plants of this character—*e.g.*, *Celmisia argentea* T. Kirk, *Astelia linearis* Hook. f., *Dracophyllum politum* Cockayne, *Carpha alpina* R. Br., *Donatia novae-zelandiae* Hook. f., *Caltha novae-zelandiae* Hook. f., *Gaimardia ciliata* Hook. f. (For full list, see Cockayne, 1909, p. 27.)

4. *After-effect of Stimuli.*

It is most important with regard to the question of the ultimate heredity of changes in form and structure, &c., brought about by an internal response of the plant to stimuli from without to inquire as to definite examples where the form, &c., persists for a reasonably long time after the stimulus is removed. The following cases bear on this subject :—

1. A prostrate form of a species of *Coprosma* (Rubiac.), which originally grew on acid peat on the Chatham Island tableland, was cultivated by me in a pot for three years, and then in ordinary garden-soil in a garden for four years more, during the whole of which time the prostrate habit remained. But all on a sudden, during the eighth year, it commenced to put forth erect shoots, and but for its unfortunate destruction would undoubtedly by this time have been on erect shrub. So assured was I that this plant would remain prostrate or stunted that I published certain remarks to that effect (1907, p. 378). So, too, with a stunted form of another species of *Coprosma*, perhaps *C. cuneata* Hook. f., collected by me in 1903 in Antipodes Island. This was grown on the rockery at

Canterbury College for six years and kept its habit, but later on it too commenced to put forth erect shoots.

2. *Coprosma Baueri* Endl. when growing on a sea-cliff is a straggling *shrub*, more or less closely flattened to the rock-surface, and puts forth nothing but long spreading horizontal shoots. Such plants bear flowers and fruit. This growth-form of the species may be referred to wind, and perhaps heat. But when *C. Baueri* grows in a coastal forest, or even when isolated on loamy clay, it is a *tree* with a stout trunk. Plants which I raised from seed, and which are now growing in the experiment-ground at Canterbury College, possess long spreading horizontal shoots—*i.e.*, they are of the shrub form, as above; but they are also developing erect shoots, and, if permitted, they will eventually grow into trees (see Plate II, fig 2). Here it is possible that the prostrate form is inherited from the race of rock-frequenting plants. But the stimulus has not been sufficient to make a really permanent race, and so the prostrate form only occurs during an early stage in the ontogeny of the individual. Similar cases of partial heredity are dealt with further on when treating of prolonged juvenile forms.

3. *Olearia Lyallii* Hook. f. (Compos.) forms a pure forest on some of the New Zealand subantarctic islands. A striking feature is the prostrate or semi-prostrate trunk, which may be referred to wind, a peat soil, and perhaps a uniform low temperature. In the interior of the forest, no matter how boisterous is the wind without, it is quite calm, and yet the seedlings are nearly always more or less prostrate at first. So, too, with the seedlings of *O. Colensoi* Hook. f. when growing on the mountains of Stewart Island.

4. The case of *Sophora microphylla* Ait. and *S. prostrata* Buchanan: This is fully discussed in this paper under the heading " Persistent Juvenile Forms " (p. 25), to which it may be well perhaps for the reader to turn and consider the case in relation to the point under discussion.

It would be beyond the scope of this paper to mention in detail instances of after-effect of stimuli in places other than New Zealand, but it is well to briefly enumerate a few of the more striking. Such are Schübler's cereals, which, grown in a northern climate, ripened their seeds earlier even when cultivated in southern countries; Cieslar's conifers, whose seeds, collected in the Alps, when sown on the plains produced plants of slow growth and small diameter; Klebs's *Veronica* and *Sempervivum*, whose striking abnormalities of inflorescence were repeated in plants raised from seed; Blaringhem's races of maize and barley originating from plants purposely damaged in a specific manner (Blaringhem, 1907); Zederbauer's experience with a form of *Capsella Bursa-pastoris* from an altitude of 2,000–2,400 m. in Asia Minor, which through four generations in Vienna maintained in part the special alpine stamp; and MacDougal's ovarial treatments, where one new induced form has maintained its character, so far, up to the fifth generation (see MacDougal, 1911, pp. 56, 57).

5. *Convergent Epharmony.*

From what has gone before, it is plain that various growth-forms of New Zealand plants may be referred with confidence to stimuli from outer factors. It has been seen also that of such forms some are merely environmental; but there are others, now to be dealt with, which are hereditary, and remain constant, unless perhaps when exposed to such a change of conditions as they would not encounter in nature.

It is a fact of the greatest significance that identical growth-forms are found side by side amongst species belonging to unrelated families. The importance of this occurrence is still more emphasized by the fact that other species in far-distant parts of the earth, growing under approximately similar conditions, may likewise possess the same epharmonic forms. That there should be this *convergent epharmony*, as it is called, seems to lend the strongest support to the view that the effect of an outer stimulus upon the plant, such as light, heat, &c., may become hereditary.

Only a few characteristic growth-forms receive attention here, and the treatment of these is quite brief. A few others are dealt with when treating of the genus *Veronica* (p. 44).

(a.) *The Divaricating Shrub Form.*

This very common New Zealand growth-form consists of much-branched often stiff and wiry stems which are pressed closely together or even interlaced, the branching being frequently at almost a right angle (see Plate III, fig. 2). Although I do not know of any example where wind has brought an exact replica of this form, a wind-shorn shrub is closely related. Still more close is the unstable form assumed by certain lianes in the open (*e.g.*, *Rubus*, *Muehlenbeckia*,* and *Clematis*) which grow in company with true divaricating shrubs. Further, the relation to shrubs of an open growth is exhibited by the already mentioned *Corokia Cotoneaster* and *Pittosporum divaricatum*, when they grow as forest-plants. *Suttonia divaricata* Hook. f. (Myrsinac.) is virtually fixed under all circumstances, though in the forest it may have a slender trunk.

The ecological factors governing this growth-form appear to be wind, in the first place, and then various other xerophytic stimuli, of which soil must play an important part.

The most instructive case of convergent epharmony in these plants is in the scrub of certain South Island montane river-terraces or river-beds, where so greatly do many of the species resemble one another that it is quite easy to confuse them. The following is an actual combination: *Pittosporum divaricatum* Cockayne (Pittosp.), *Rubus subpauperatus* Cockayne (Rosac.), *Discaria toumatou* Raoul (Rhamnac.), *Aristotelia fructicosa* Hook. f. (Elaeocarp.), *Hymenanthera dentata* R. Br. var. *alpina* T. Kirk (Violac.), *Corokia Cotoneaster* Raoul (Cornac.), *Coprosma propinqua* A. Cunn., *C. parviflora* Hook. f. (Rubiac.). *Hymenanthera* would frequently be absent or confined to specially stony ground. There would also probably be one or more species of *Veronica* and *Carmichaelia*, but their growth-forms are different.

The divaricating growth-form also occurs in the following families: *Polygonaceae*, *Ranunculaceae*, *Leguminosae*, *Rutaceae*, *Icacinaceae*, *Malvaceae*, *Mysinaceae*, and *Compositae—i.e.*, in fifteen families altogether, all of which have likewise members with altogether different growth-forms. Generally speaking, the earlier juvenile form of these plants is mesophytic.

(b.) *The Cushion Form.*

Every transition exists between the open circular mat-like form and dense unyielding cushions. It is merely a question of degree in reduction of internodes and closeness of growth. The genus *Celmisia* shows

* *M. Astoni* Petrie, most closely related to the liane, *M. complexa*, is a divaricating shrub.

Fig. 1.—Sophora microphylla.
Juvenile divaricating form.

Fig. 2.—Pittosporum divaricatum.
A shrub of the divaricating growth-form.

Face p. 20.]

Podocarpus nivalis.
On left, shade form; on right, sun form. Plants from Otira Gorge.

straggling mats in *C. discolor* Hook. f. and *C. Walkeri* T. Kirk, loose circular cushions in *C. viscosa* Hook. f., and true dense cushions in *C. sessiliflora* Hook. f. and *C. argentea* T. Kirk.

Frequently the epharmony of such cushions can be seen clearly in one and the same species, as in the tiny taxad *Dacrydium laxifolium* Hook. f., which forms cushions on dry pumice at 1,200 m. altitude near Mount Ruapehu, but which growing amongst other shrubs under more mesophytic conditions is frequently a straggling shrub, or when in colonies on sour peaty ground merely a close turf.

The cushion form culminates in the great amorphous masses of certain species of *Psychrophyton* and *Haastia*, which grow on alpine rocks* exposed to sun, frost, and wind, or at times, in the case of *R. Goyeni* T. Kirk, of Stewart Island, on wet peat.

Excepting with regard to the physiologically different bryophyte cushions of moors or wet forests, the cushion form is governed by strong xerophytic conditions, and the same species may thrive either in physically or physiologically dry stations—*e.g.*, *Phyllachne Colensoi* Berggren (Stylid.), *Psychrophyton Goyeni* Beauverd (Compos.).

The form under consideration occurs in the following families : *Taxaceae*, *Gramineae*, *Cyperaceae*, *Centrolepidaceae*, *Juncaceae*, *Portulacaceae*, *Caryophyllaceae*, *Leguminosae*, *Violaceae*, *Thymelaeaceae*, *Umbelliferae*, *Boraginaceae*, *Scrophularinaceae*, *Plantaginaceae*, *Stylidiaceae*, and *Compositae*.

Epharmonically similar cushions occur amongst different genera and families in high mountains everywhere. Certain erect shrubs when wind-swept become virtually cushions.

(c.) *Lianes.*

Climbing-plants have most certainly descended from non-climbing species which through shade and moisture have grown upwards out of the lower tiers of vegetation in a stratified association. Many transitions between climbing and non-climbing plants can be observed, and these, considered along with the heredity of the climbing habit and its strong differentiation, afford weighty support to a belief in the heredity of epharmonic characters.

The fern *Hypolepis distans* Hook., which generally gives no hint of a propensity to climb, when growing alongside a support may lengthen its fronds for considerably more than 1 m., though at this length they would fall but for the support. On the rhachis are minute excrescences, which, though certainly not adaptations for the purpose,† assist the frond to maintain its position. The climbing form of *Pteridium esculentum*, already noted, is specially interesting because of its hint at winding. So, too, with the *scrambling* liane *Lycopodium volubile* Forst. f., which, gaining a thin support, *winds* freely, the winding being in this case an hereditary characteristic.

The case of *Fuchsia Colensoi* Hook. f., already mentioned, is of especial moment. This is a shrub in the open, and at times a scrambling liane in the forest. There can be little doubt that this latter habit is hereditary to some extent, and it is possible that there may be climbing and non-climbing races. This is the more likely as the "species" is considered variable, and large forms are said to "almost pass into *F. excorticata*" (Cheeseman, 1906, p. 187), which is a small tree or shrub, but never a liane.

* *Haastia pulvinaris* appears to grow on shingle-slip, and not on rock, so far as I have observed; but I am also advised that at times it grows on rock.

† Strictly speaking, there is no "purpose" in any adaptations, but it is often convenient to speak teleologically.

In the case of *Rubus cissoides* A. Cunn. var. *pauperatus* T. Kirk there is no question of distinct races, although there are certainly two epharmonic growth-forms. The one is a high-climbing liane growing in forests. It is provided more or less abundantly with leaves, and produces plenty of flowers and fruit. But in the open, on hillsides fully exposed to wind and sun, it forms rounded bushes of interlacing twigs, has its leaves reduced to midribs, and never produces flowers. It is, in fact, a xerophytic form, governed by the non-forest conditions, and its presence depends upon seeds being brought from the forest-plant by birds. Seedlings raised by me from the forest-plant were leafy in an early seedling stage*; this was followed by the epharmonic leafless form, which, although hereditary, can only persist so long as xerophytic conditions are maintained. Plants growing in the shelter of a cliff may have a few leafy shoots which can bear flowers and fruit. *Rubus subpauperatus* Cockayne, closely related both as a species and as a growth-form, has also a forest form and a xerophytic form, but in this case both produce flowers. The adult flowering forms of the root-climbing lianes *Metrosideros scandens* Sol. and *M. florida* Sm. may become shrubs in the open, an analogous case to that of the artificially raised tree-ivy of gardens. It is highly probable that other climbing species of the genus behave in a similar manner.

The genus *Clematis* is represented by eight species† in New Zealand. All are more or less variable, and some of the species appear to "run into" one another. Six may be considered mesophytes; they are forest-plants, or some climb amongst shrubs. These species are abundantly furnished with leaves. But the var. *rutaefolia* Hook. f. of *C. Colensoi* Hook. f. grows under more xerophytic conditions, and, in accordance with these, it is smaller than the type, the leaves are more cut and present less transpiring surface; perhaps it is a fixed form. *C. marata* is subxerophytic; it grows in the open, frequently climbing into the branches of the xerophytic *Discaria toumatou;* its stems are slender, brownish-green, pubescent, and interlaced, and its leaves much reduced. Finally, *C. afoliata* Buchanan is a true xerophyte; it is virtually leafless; the stems are green and function as leaves; they are rush-like, grooved, have the stomata in the grooves, and are generally closely intertwined — *i.e.*, the growth-form is identical with that of the above *Rubus*, and approximates to the divaricating form. The seedling has plenty of leaves, and when the adult grows in the forest this juvenile state may persist and even flower. It must be remembered that this range of forms of *Clematis*, which vary from forest mesophytes to an almost divaricating leafless shrub form, are all presumably descended from one ancestor, and that even now many are connected by intermediates, while one species is epharmonically mesophytic or xerophytic, according to its station.

(d.) *The Prostrate Form.*

There are various modifications of the prostrate form, which depend chiefly upon closeness of branching and rooting-capacity. Here there are only mentioned those with more or less straggling stems, which may or may not bear adventitious roots. On certain subalpine moors a number

* See also figs. 229, 230, Goebel, 1905, pp. 353, 354.

† *C. quadribracteolata* Col. is omitted, as it seems to me merely a variant of *C. marata* J. B. Armstrong. Nor do I know anything regarding the vars. *depauperata* Hook. f. and *trilobata* Kirk of *C. parviflora* A. Cunn.

Fig. 1.—Veronica chathamica.
Cutting planted vertically but growing horizontally, thus showing an hereditary character.

Fig 2.
1. Veronica loganioides. 2. V. cassinioides. 3. Reversion Shoot of V. tetragona. 4. V. tetragona. × 3.

Face p. 22.

Fig. 1.—Sophora tetraptera.
Young tree of Chatham Island form growing erect with straight branches.

Fig. 2.—Sophora tetraptera.
Seedlings of Chatham Island form.

of plants of this class may grow side by side belonging to the genera *Dacrydium*, *Podocarpus* (Taxac.), *Leptospermum* (Myrtac.), *Styphelia* (Epacrid.), *Coprosma* (Rubiac.), *Veronica* (Scrophular.), and *Celmisia* (Compos.). In some cases the prostrate form is here hereditary, while in others it is unfixed and depends merely upon the station.

The combination of species forming the shrub steppe on the subalpine volcanic plateau, North Island, contains a considerable percentage of prostrate shrubs, some of which are more or less erect under less xerophytic conditions.

Coastal rocks favour the prostrate form. Thus in such a situation near Island Bay, Wellington, there are *Hymenanthera crassifolia* Hook. f. (more or less hereditary), *Coprosma Baueri* Endl. (hereditary when juvenile), *Veronica macroura* Hook. f. var.* (perhaps hereditary when juvenile but erect when adult).

Other veronicas of coastal rocks are more or less prostrate, and this is strongly hereditary in *V. chathamica* Buchanan—so much so that a shoot grown vertically in a pot quickly assumed the horizontal direction (see Plate V, fig. 1).

An interesting instance of non-hereditary convergent epharmony of this growth-form is the wiry undergrowth of three species of *Coprosma* beneath the tussocks of *Danthonia antarctica* Hook. f. at some 250 m. altitude in Auckland Island. One of the species, *C. foetidissima*, is "normally" a tall twiggy shrub, and the other two are medium-sized divaricating shrubs.

6. *Persistent Juvenile Forms.*†

About two hundred species of New Zealand vascular plants, belonging to thirty-seven families, show a more or less well-marked distinction between the juvenile and adult stages of development, while in perhaps one hundred species the differences are very great indeed. The most interesting cases are those in which a juvenile form remains permanent for a number of years, so that in its ontogeny the individual passes through two, or even more, distinct stages, and not infrequently through two

* I am inclined to think it would be better to consider this a species. It differs considerably from the typical form, which grows in the East Cape district.

† Heteroblastic development is a world-wide phenomenon which has not received nearly the attention it deserves from writers on evolution. It is its occurrence in so many endemic species in New Zealand that makes data from this region of special interest. In 1879 I. Bayley Balfour recorded a number of striking examples from the Island of Rodriquez—*e.g.*, *Clerodendron laciniatum* Balf. f., reminding one of the New Zealand *Nothopanax simplex* Seem.; *Pyrostria trilocularis* Balf. f.; *Fernelia buxifolia* Lam., a rubiaceous plant, evidently when juvenile somewhat of the divaricating shrub form; and *Mathurina penduliflora* Balf. f. (Turnerac.), which has long narrow juvenile and broad adult leaves, as in *Parsonsia heterophylla* A. Cunn. and other New Zealand plants. Altogether seventeen species of trees and shrubs and one herb out of 175 species of spermophytes show marked dimorphism. Goebel (1889–93) gives a number of examples of heterophylly, &c., referring the phenomena in some instances to direct outer stimuli, and he deals further with the matter in his "Organography of Plants" (1900–5) and his "Experimentelle Morphologie" (1908). Diels (1906) goes into the matter at considerable length, using many important illustrations from his observations in Western Australia. As for the phenomenon in New Zealand, Hooker was the first to refer to it, in his splendid "Introductory Essay to the New Zealand Flora" (1853, p. 1). Kirk gives many details in his "Forest Flora" (1889), and these are supplemented by Cheeseman in his Manual. Finally, my own writings since 1899 contain a good deal of scattered information not previously published.

growth-forms. Although the juvenile and adult forms may be so distinct as to virtually represent different species, yet in many cases the adult does not appear suddenly, but intermediate stages occur. In these there is very frequently a combination of characters which are primarily quite distinct. Thus in the intermediate leaf-form of *Parsonsia capsularis* R. Br. (see fig. 2) there are all kinds of combinations between the early seedling *short rounded* leaf and the later *long narrow* one. *Elaeocarpus Hookerianus* Raoul also exhibits a remarkable series of leaf-combinations, for which see fig. 3. Further, there are transitions of general growth-forms, as when *Sophora microphylla* Ait. commences the adult stage with stout semi-erect but still flexuous stems. It seems clear from the above facts and from those that follow that the possibilities of both juvenile and adult are latent in the one plant, but each requires its necessary stimulus to set it free in its entirety. If the stimulus is not sufficient, then one or the other

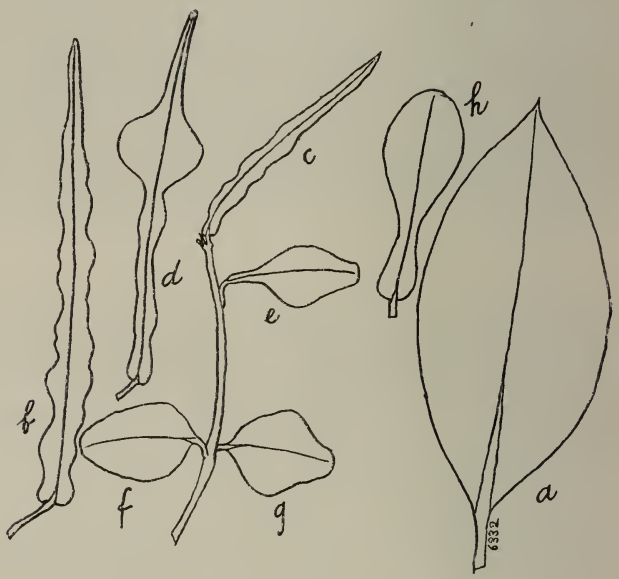

Fig. 2.—Various Forms of Leaf in Parsonsia heterophylla.

a, adult leaf; *f* and *g*, earliest form of leaf, but often more circular; *d*, *e*, and *h*, transitional forms; *b* and *c*, second type of juvenile leaf. Life size.

form may persist, or there may be a combination of characters, as in the transitional forms. In any case, heredity comes in, and this has attained to such a degree that under normal conditions there is a juvenile stage of a certain average duration, a transitional stage, and an adult. Different degrees of heredity have arisen, as I believe, in proportion to the length of time the original stimuli have functioned, combined with their intensity, and abnormal increase or decrease of stimulus can in many instances hasten or retard the procession of events. There is in some measure, perhaps, species-making going on before our eyes. This is best seen in those cases where the juvenile form produces flowers, for if progressive development should cease at this point what is virtually a species distinct from

the adult has appeared. Should such a flowering juvenile form be epharmonic, then, as Diels has shown, we are face to face with a case of ontogenetic evolution (1906). In some of the species the juvenile and adult forms can both clearly be shown to be epharmonic (*e.g., Veronica lycopodioides* Hook. f., *Carmichaelia subulata* T. Kirk, *Discaria toumatou* Raoul, *Potamogeton Cheesemanii* A. Bennett, *Clematis afoliata* Buchanan); they can even be experimentally produced or prolonged. In other cases epharmony can only be inferred (*Sophora microphylla, Podocarpus dacrydioides, Rubus schmidelioides*); and in others it is more or less obscure (*Parsonsia heterophylla, Pseudopanax crassifolium* C. Koch, *Pittosporum patulum* Hook. f.). There is, therefore, a gradual gradation from the known to the unknown, but, as the main features are alike throughout, it is reasonable to assume an epharmonic origin in most cases, notwithstanding that contradictory examples occur, and to consider that there is a relation between the age of the form and its relative stability. Here there is no attempt to go thoroughly into the phenomenon under consideration; certain typical examples are alone discussed.

The significance of the divaricating growth-form has been already noted. It may be remembered it is eminently xerophytic, extremely well defined, and present in various unrelated families. But this form is not confined to shrubs alone, but appears as a persistent juvenile stage in the life-history of certain plants, which are thus xerophytic shrubs for some years and finally ordinary mesophytic forest-trees. The following are examples: *Pennantia corymbosa* Forst. (Icacinac.), *Hoheria angustifolia* Raoul, *Plagianthus betulinus* A. Cunn. (Malvac.), *Sophora microphylla* Ait. (Legum.), *Elaeocarpus Hookerianus* Raoul (Elaeocarp.).

The case of *Sophora microphylla* Ait. is the most instructive. It must be considered along with the remaining species—*S. tetraptera** J. Mill., *S. grandiflora* Salisb., and *S. prostrata* Buchanan. All the species commence with hypogeal cotyledons, and the first, or first two, leaves are simple and arrested structures, but the succeeding ones are pinnate and of the adult type. The primary stem is erect and somewhat flexuous (see Plate VI, fig. 2), except in the case of *S. grandiflora*. This species continues to grow erect, and in time develops into a small tree. There is no heterophylly beyond the early simple leaves, and no hint even of any xerophytic shrub stage. With *S. microphylla* the progress of events is very different. Here the early seedling soon develops into a xerophytic divaricating shrub, and so it will remain for some ten years or more, and attain a height of perhaps 1·4 m. before the more or less erect branches shoot upwards, the forerunners of the mesophytic tree form (see Plate III, fig. 1). It is quite common to see a specimen which is shrub at the base and tree above. Occasionally the upper part of the shrub form will blossom, but I do not think this ever happens before the tree itself flowers. *Sophora prostrata* never grows out of the shrub state; *it is a fixed juvenile form*, which, moreover, reproduces itself true from seed. Between *S. microphylla*, and *S. prostrata* there are intermediates. With regard to *S. tetraptera*, the juvenile plant differs but little from the adult (see Plate VI, fig. 1), though it has for a time a few flexuous twigs. I have

* Under this name I include the Chatham Island plant, a form in the neighbourhood of Auckland City, and the Chilian plant. As for the Auckland plant, I do not know its juvenile state well enough to speak with certainty, but in any case its behaviour, if different from that stated, would not in any way affect my conclusions.

seen only one specimen raised from Chilian seed,* and it resembles closely the Chatham Island plant. *S. microphylla* and *S. prostrata* grow side by side at the lower Waimakariri Gorge, Canterbury Plain.

In the above case of *Sophora* the adult form is probably the stem form, and the xerophytic divaricating shrub form an epharmonic adaptation which arose during a probable period of drought on the east of the Southern Alps at the time of the glacial period (see Diels, 1896, and Cockayne, 1900). In certain parts of the problematical Greater New Zealand where the climate still remained sufficiently wet the ancestral *Sophora* would remain unchanged ; so we still see *S. grandiflora* in the East Cape district and *S. tetraptera* in the Auckland district and the Chatham Islands. In the South Island there is only *S. microphylla* and *S. prostrata*, in the former of which the xerophytic stimulus never evoked an absolutely hereditary form, whereas in the latter the effect of the stimulus is much more deep-seated. To what extent such a stimulus can leave its mark is shown in the forest-tree *Elaeocarpus Hookerianus*, which at any age may put forth reversion shoots high up the trunk or on the branches. The heteromorphy in the other species listed above may be similarly explained. There is first of all a short-lived erect mesophytic stage, then a long-persisting xerophytic stage, and a final adult mesophytic stage. The first stage, suited as it is to shelter by ground-plants, &c., is epharmonic ; it may also be considered a survival from the ancestral plant. The second (xerophytic) stage was epharmonic during the steppe-climate period of the eastern South Island, but is certainly beneficial no longer ;† and the adult stage is more or less a return to the original form, but now called forth by the present mesophytic conditions. According to this supposition, it is considered that the tendency to both xerophytic and mesophytic form is latent in the plant, and that one or the other will appear as soon as the necessary intensity of stimulus is reached. Until that is the case, whichever form is the more hereditary—*i.e.*, the more strongly fixed—will persist, even though it is far from being epharmonic.

In a considerable number of instances there is a mesophytic juvenile stage and a xerophytic adult. In this class the present mesophytic conditions are not sufficient to inhibit the strongly hereditary xerophytic form, which also in a number of cases is in harmony with the xerophytic stations affected by these plants. The following examples of this and other persistent juvenile forms may be noted :—

(1.) Shrubs which are leafy as juveniles, but leafless as adults, when they have flat or terete green assimilating stems — *e.g.*, species of *Carmichaelia*,‡ *Notospartium*, and *Corallospartium*. How unstable really is the xerophily of many species of *Carmichaelia* is shown by their abundant production of leaves in shady stations.

(2.) Shrubs with an abundance of leaves, sometimes very thin, when juvenile, but of the cupressoid form when adult—*e.g.*, certain *Taxaceae* (see Griffen, 1908), whipcord veronicas, and some species of *Helichrysum* belonging to the section *Ozothamnus*.

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* The seed was very kindly sent to me by Dr. Eug. Autran, of Buenos Ayres, and the seedlings were raised by Mr. T. W. Adams, to whom I am greatly indebted.

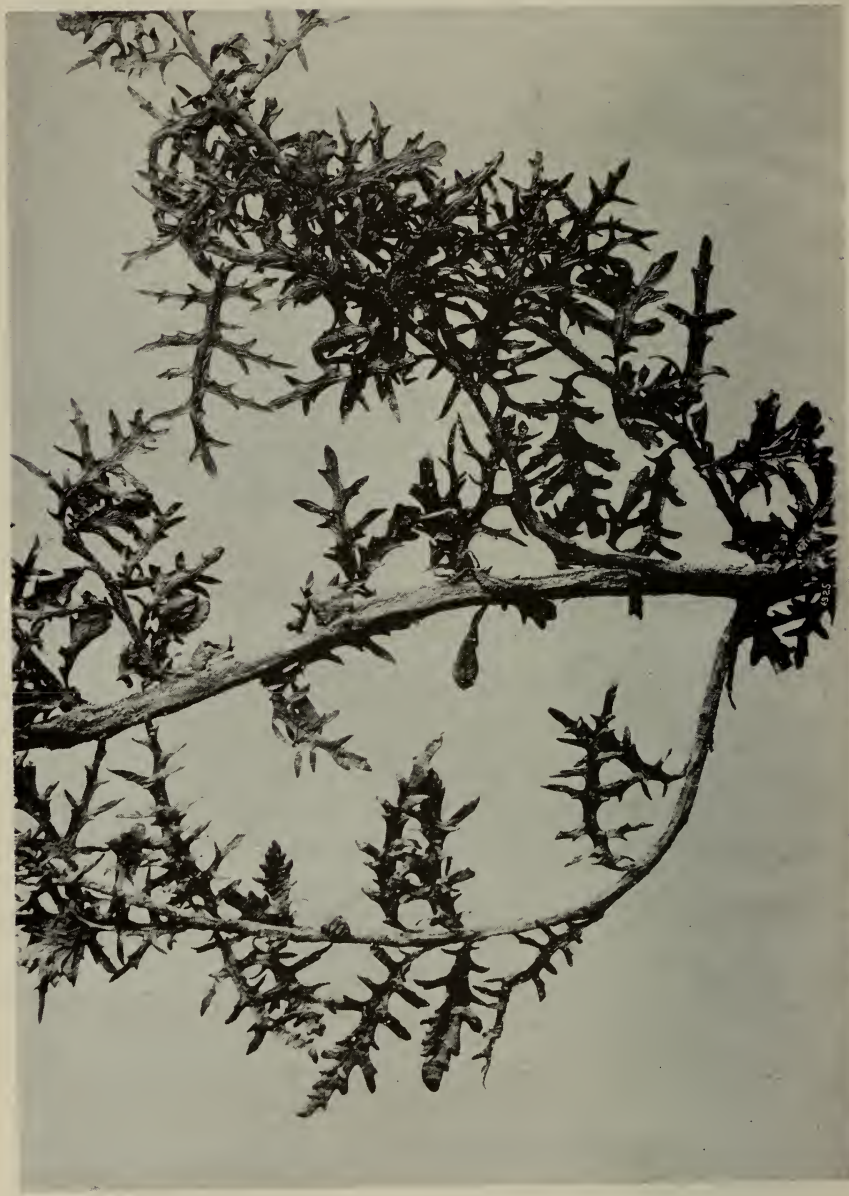
† The divaricating form of *Elaeocarpus Hookerianus* and the juvenile *Pseudopanax crassifolium*, with its thick, narrow, stiff, deflexed leaves, certainly seem out of place in a rain forest, where they are assuredly *not* epharmonic structures.

‡ *Carmichaelia gracilis* J. B. Armstrong is leafy in the adult ; it is a scrambling iane, and grows in wet ground or swamps. *C. grandiflora* Hook. f. is deciduous, but abundantly leafy in spring and summer. *C. odorata* Colenso is also leafy.

Fig. 1.—Aristotelia fruticosa.
On left, juvenile; on right, adult.

Fig. 2.—Pennantia corymbosa.
On left, adult; on right, semi-juvenile in bloom.

Face p. 26.]



Pittosporum divaricatum.
Seedling of Westland form. × 3.

The juvenile stage in these plants, the *Taxaceae* excepted, does not usually persist for any long period, and may be compared to the first stage in *Sophora* and the various divaricating shrubs. But in the veronicas, as I have shown, it can be made to persist artificially for years, so long as the plant is kept in moist air. Further, reversion shoots are frequent even on such a typical xerophyte as *Helichrysum Selago*, while it seems probable that hereditary semi-juvenile races occur of *Veronica tetragona*‡ Hook. and *V. lycopodioides** Hook. f. These are further dealt with on p. 45. In the case of *Dacrydium laxifolium* Hook. f., a prostrate or suberect mountain-shrub, growing in wet ground or bogs, it is quite common to find juvenile plants with the lax spreading leaves blooming freely, and never developing into the cupressoid adult. The juvenile stage of *D. intermedium* T. Kirk frequently becomes a tree, and flowers and fruits as abundantly as the "normal" adult growing in the same swamp forest. This flowering juvenile was given the varietal name *gracilis* by Kirk.

(3.) Nearly all the divaricating shrubs have a primary juvenile mesophytic stage. This is generally but transitory, but I have already shown in the case of *Pittosporum divaricatum* and *Corokia Cotoneaster* how the early stage may persist in the forest and reach its full stature. Semi-juvenile plants of the *Pittosporum* may also flower.

Aristotelia fruticosa Hook. f. (Elaeocarp.) is an interesting case. The early seedling is erect, mesophytic, and, compared with the adult, shows a most remarkable variety of leaves. These are often more or less lanceolate, toothed, lobed, or pinnatifid (see Plate VII, fig. 1). Later on the divaricating form appears, which may finally be of the most intense character, the small frequently more or less oblong leaves being scanty, and the ultimate shoots almost spinous.† But this form is not truly stable, plants growing in an adjacent *Nothofagus* forest being much more mesophytic. Even when quite in the open, there are forms still divaricating to some extent, it is true, but juvenile so far as leaf-form goes, and these develop no further, and blossom. This semi-juvenile fixed form should be considered older than the "normal" adult, and it may represent the pre-glacial plant.

Suttonia divaricata Hook. f., so far as I have observed, has no seedling mesophytic stage. But even this "well-fixed" species when growing on the Poor Knights Islands has leaves three times the size of those of the usual stations.

(4.) *Nothopanax simplex* Seem. and *N. Edgerleyi* Harms. (Araliac.) have also a mesophytic juvenile form, but the adult must be considered mesophytic likewise. Both are rain-forest plants, while the former is found also in certain subalpine scrub. I have not full details regarding *N. Edgerleyi*, the juvenile form of which sometimes so closely resembles that of *N. simplex* that I, for one, cannot distinguish between them, so my remarks are confined to the latter species. The early stage has a fern-like, much-cut, thin and large leaf. This is succeeded by a second stage with ternate

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* Cheeseman found a semi-juvenile form of *V. tetragona* at the base of Tongariro and Ruapehu, and writes (1908, p. 281), "Probably it is an intermediate state between the juvenile stage and the fully matured one, but if so it must persist for many years." Mr. Poppelwell collected a form of whipcord *Veronica* on the Garvie Mountains, a plant of which has kept the semi-juvenile form for two years in my garden. So, too, from some notes sent to me by Mr. F. G. Gibbs it is evident that he has had in cultivation a very similar plant.

† *Hymenanthera dentata* R. Br. var. *alpina* T. Kirk also develops semi-spines under very dry conditions.

leaves, and this by the simple- and thicker-leaved adult. In some localities the much-cut form is suppressed to some extent, or almost entirely absent (Auckland Islands; but see Cockayne, 1904, p. 249,* and pl. 11). The closely related *Nothopanax parvum* Cockayne also seems to lack a cut-leaved stage. *N. anomalum* Seem., although frequently a forest-plant, has a juvenile mesophytic form with small ternate leaves and an adult divaricating shrub form connecting the ternate-leaved form of the genus with the divaricating shrubs.

(5.) In this class come a considerable number of plants which cannot with any confidence be referred in their different stages to special outer factors. Take the case of certain species of *Pseudopanax* (Araliac.): two (*P. crassifolium* C. Koch and *P. ferox* T. Kirk) have the curious narrow deflexed juvenile leaves and unbranched stem, but in *P. lineare* C. Koch, a subalpine shrub, the virtually similar juvenile leaves are erect; and in *P. chathamicum* T. Kirk they are wanting altogether, the juvenile and adult leaves not being very different.

The primary seedling leaves of *P. crassifolium* are somewhat similar in form to the adult, but, of course, much smaller. They are erect, and never deflexed. *P. ferox*, on the contrary, commences with narrow-linear toothed leaves of the second stage, which are not erect, but horizontal for a time.

The small-leaved juvenile and the large-leaved adult forms of the root-climbing fern *Blechnum filiforme* Ettingsh. cannot be explained epharmonically, though there probably is, or has been, some relation of the sort, since the first-named is the common ground form (creeping form) and the large-leaved the climbing form. Nor can I suggest any explanation of the two juvenile leaf-forms of *Parsonsia heterophylla* and *P. capsularis* R. Br. (see fig. 2). In the former species the long narrow-leaved shoots occasionally flower, and in the latter there is a fixed flowering juvenile race occurring in the uplands of the South Island which I consider a distinct species.

Weinmannia racemosa L. f. and *W. sylvicola* Sol. (Cunoniac.) are two closely related species whose flowers are virtually identical, and which differ merely in the adult leaf of the first-named being entire and of the other compound. The early seedlings of both are identical; they are erect, their leaves are simple, toothed, thin, and hairy. Then comes a second stage, in which in *W. racemosa* the leaves are ternate, and in *W. sylvicola* both ternate or pinnate. At this stage, when both plants are merely bushy shrubs, they can flower, and need not develop into trees. Frequently on the heath lands of northern Auckland *W. sylvicola* attains 3–4 m. in height; the leaves are large, and have many leaflets, yellowish in colour, and although Mr. H. Carse, myself, and others have seen hundreds of these tall juvenile plants we have never seen them in flower. *Ackama rosaefolia* A. Cunn. (Cunon.), if not actually a companion plant, grows near by on the forest's outskirts, &c., and its adult form so much resembles this juvenile *Weinmannia* that no one could distinguish flowerless examples one from the other without a knowledge of certain quite obscure differences.† The adults of the two species of *Weinmannia* are lofty forest-trees. From the above it seems reasonable to conclude that *W. sylvicola* is merely a fixed

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* Through a clerical error "entire-leaved" is printed several times instead of "simple leaves." The leaves are more or less serrate, but compared with the juvenile they are virtually "entire."

† The distinctions given by Kirk in the "Forest Flora," p. 113, do not hold in practice, so far as the leaf is concerned.

juvenile stage of *W. racemosa*, or else that the former is the stem form and *W. racemosa* a mutation or an epharmonic variant that has become fixed.

Several instances of juvenile blossoming have already been given. The following are additional examples:—*Ranunculus Lyallii* Hook. f. (the juvenile has a reniform leaf and the adult a peltate; reversion leaves occur as a result of bad nutrition; there are intermediates between the two types of leaves): *Pittosporum tenuifolium* Banks & Sol. (the juvenile seems to me identical with *P. nigrescens* Hort.,* the plant so much used in certain parts of New Zealand for hedges; as a hedge-plant the juvenile form is alone to be seen, it being preserved by the constant cutting†): *Clematis indivisa* Willd.: *Dracophyllum arboreum* Cockayne: *Agathis australis* Salisb.: *Nothopanax Edgerleyi* Harms. (one semi-juvenile form blooms and is the var. *serratum* T. Kirk): and *Anisotome filifolia* Cockayne and Laing. There are also a number of forest-trees which remain in the shrub stage and flower (see Cockayne, 1908, p. 22).

Each of the above cases would need deciding on its merits as to whether the flowering juvenile might be the beginning of a new line of descent, or was merely a reversion. I will only discuss the case of *Anisotome filifolia* Cockayne and Laing.

This is an herb with the leaves in an erect rosette and a long tap-root which grows upon stony debris where there is a steppe climate in the mountains of Nelson, Marlborough, and Canterbury. The leaves are grassy, some 20 cm. long, ternately divided into segments which are filiform if the plant grows in the open, but 3 mm. broad, or broader, when growing in the shade. Both forms produce flowers. Seedlings raised from the filiform xerophytic form had broad segments (see fig. 38, pl. 12, in Cockayne, 1900, and also pp. 295–97). The broad leaves are certainly beneficial for promoting rapid growth in a dry station, nor will the seedling be exposed to as rigorous surroundings as the adult, protected as it will be by the stones. Its form is therefore epharmonic. The broad-leaved adult of the shade is then a flowering juvenile, which may or may not be "fixed," but, if fixed, it would be an example of ontogenetic evolution, the arrival of the new species dating from the first time the juvenile plant reproduced its like from seed.

Many of these heteroblastic species put forth when adult typical juvenile or semi-juvenile shoots, as the case may be. Such may often be traced to a special stimulus. Thus, stems of *Phyllocladus alpinus* Hook. f. when prostrate on wet soil may bear abundance of true leaves, but those in a drier position have phylloclades only; *Discaria toumatou* Raoul cropped by rabbits produces leafy shoots only‡; and *Ranunculus Lyallii* Hook. f. grown in dry soil under unfavourable conditions may develop a certain number of reniform seedling leaves.

The position of the reversion shoots upon the plant differs in different species. Very often they are confined to near the base, in which case they may be merely developed resting buds. *Pseudopanax crassifolium* C. Koch and *Weinmannia racemosa* L. f. when cut to the ground regenerate from the stump by means of juvenile shoots. *Pittosporum tenuifolium* Banks & Sol., as a hedge-plant, remains permanently juvenile through frequent

* H. M. Hall (1910) is of the same opinion.

† Other species of *Pittosporum* also occur at times in these hedges through the sowing of mixed seed, and so other forms of leaf may be occasionally present.

‡ I noted one adult plant growing on a sand-dune that was almost, if not entirely, without spines, the xerophytic station notwithstanding.

clipping. The shrubby bases so frequently seen of *Pennantia corymbosa* Forst., *Hoheria angustifolia* Raoul, &c., above which the flowering and quite different adult rises, are not very long-lived, but finally die and are cast off. In some cases the distinction between juvenile and adult is equally great, as in the above, but the stability of each form is weaker, and the power of the cell derived through heredity to produce one or the other is present in every shoot, no matter how far from the base, reminding one somewhat of the behaviour of a "graft hybrid." Examples are: *Dracophyllum arboreum* Cockayne, whipcord veronicas, *Podocarpus dacrydioides* A. Rich, *Aristotelia fruticosa* Hook. f. In *Elaeocarpus Hookerianus* Raoul reversion shoots occur high up the tree, but I have not noted them in the uppermost branches. In these last-cited examples an observable stimulus does not seem necessary to bring forth the special form; it is rather as if very little indeed —probably some slight internal change—can suffice to upset the equilibrium of the cell upon which one or the other form depends. An analogous example is a variegated form of *Veronica salicifolia* which originated spontaneously in the garden of the late Mr. W. Gray, of Governor's Bay, for many years an enthusiastic cultivator of New Zealand plants. The first leaves of each shoot have an irregular band of green down the centre of every leaf, but as these become older chlorophyll gradually invades the pale portion until the leaf becomes normally green. Shade leaves are at first without any chlorophyll.

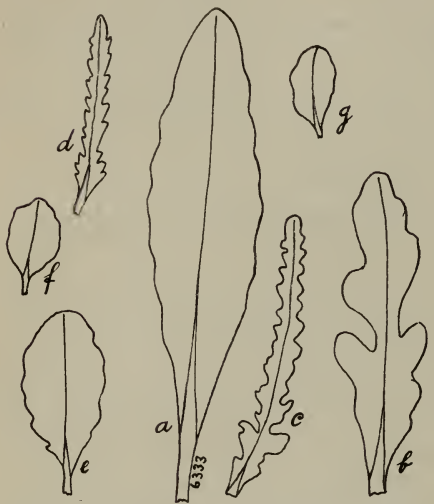

Fig. 3. — Leaf-forms of Elaeocarpus Hookerianus.

a, small adult leaf; *b*, transition to adult; *c* and *d*, early long narrow form; *e*, *f*, and *g*, early obovate short form. The long narrow and short obovate or rotund leaves are associated with divaricating branching. Life size.

VI. Hybridization.

Hardly anything is known as to the occurrence of wild hybrids in New Zealand. But field observations on this head are, in any case, merely suggestive, and, at most, pave the way for experiment.

Long ago hybrids were raised in cultivation by Mr. Anderson Henry and others in Great Britain from some of the large-leaved lowland species of *Veronica*. What I take to be hybrids—one especially from *V. pimeleoides* Hook. f.—have originated spontaneously in the semi-wild collection of indigenous plants in the Christchurch Domain. Mr. D. L. Poppelwell has sent me a hybrid from his garden which he considers *V. salicifolia* × *V. decumbens*. It is somewhat of the *salicifolia* type, but with small glossy leaves; I have not seen the flowers. Recently Mr. A. Lindsay, of Edinburgh, has raised one or two hybrids of which the parents are known. The

most important of these is *V. Hectori* Hook. f. (a "whipcord veronica") × *V. pimeleoides* Hook. f. (a small glaucous-leaved straggling rock-plant with blue flowers), and the result is a plant said to be identical with or near to *V. epacridea* Hook. f. If this is true, it opens up much suspicion as to the validity of many species of the genus in New Zealand, and, at any rate, in the case of variation in general, as some of the species are gynodioecious,* hybridism may be the simple explanation.

Mr. McIntyre, who had charge of the famous collection of New Zealand plants of the late Mr. H. J. Matthews, raised a good many hybrid forms of *Celmisia*, all of which appeared to have the so-called *C. verbascifolia*† as one of the parents. I have seen a *Celmisia* on Jack's Pass which was most likely a hybrid between *C. spectabilis* and *C. coriacea*. Also, *C. mollis* Cockayne is possibly of hybrid origin, with *C. spectabilis* as a parent. In short, hybridization may account for some of the variation in *Celmisia*. *Acaena*, again, is a very variable genus, which suggests hybridization. Buchanan was the first to call attention to this matter, and he described a supposed hybrid between *A. Sanguisorbae* Vahl. and the introduced *A. ovina* A. Cunn. (1871, p. 208). Kirk reduced this to var. *ambigua* of *A. ovina*, notwithstanding that the inflorescence is altogether different from that of that species. Bitter (1911, pp. 297–321) describes fifteen hybrid forms of *Acaena*, illustrated by figures of leaves, in which varieties of *A. Sanguisorbae*, *A. microphylla*, and *A. glabra* are parents, one or the other. These forms have originated spontaneously in the Bremen and other Continental botanical gardens. Bitter is convinced they are true hybrids, and that the only question that can be raised is as to the parentage that he suggests for them. A full account is given of each form.

I have seen, judging from the capsule, what appear to be wild hybrids between *Phormium tenax* Forst. and *P. Cookianum* Le Jolis. A good deal of the variation in *P. tenax* may be due to hybrid elementary species, for that it is made up of many such entities seems very probable.‡

Melicope Mantellii Buchanan is supposed by some to be a hybrid between *M. simplex* A. Cunn. and *M. ternata* Forst. (see Kirk, 1889, p. 118). I have proved that it comes true from seed, and in the absence of experimental evidence it is quite as reasonable to suppose it is an elementary species connecting *M. simplex* and *M. ternata*. All three have ternate juvenile leaves; *M. ternata* remains at this stage but with much larger adult leaves, *M. Mantellii* has both simple and ternate leaves in the adult, and *M. simplex* is a divaricating shrub when adult with simple leaves.

VII. The Struggle for Existence.

Plant-ecologists have many opportunities for observing various phases of the struggle for existence. They have also some opportunity of judging

* I am indebted to Professor I. Bayley Balfour, F.R.S., for calling my attention to this phenomenon in our veronicas, which he was the first to discover. I had previously wondered why certain species in my garden never produced seed, and others very little, and had ascribed it to the absence of the proper pollinating insect. How far the phenomenon is present in wild plants has not been as yet ascertained.

† Probably *C. verbascifolia* Hook. f. = *C. Brownii* Chapman.

‡ The Chatham Island form, with its thin broad leaves, is distinct, so far as I know, rom any of the mainland forms.

as to the likelihood of extremely small* variations being preserved or the contrary. It must be understood that the "struggle" is not only between the individuals of the competing species, but also between these and their environment. This was distinctly stated by Darwin, who refers to the struggle for life against the drought on the edge of a desert (1899, p. 46). In many instances this struggle with outer circumstances is the more important; it is also the deciding factor as to what plant-form can gain a footing in the first instance.

The formations themselves offer various conditions according as they are "open" or "closed," for in the former there is apparently room for new-comers, whereas in the latter it is almost impossible for a species from without to gain admittance. This fact is of major importance, for, amongst other matters, it has a strong bearing on the much-debated question regarding former land connections with distant islands as opposed to bird carriage, &c., across *wide*† areas of ocean. The case of New Zealand as a whole is of great interest in this regard, especially as many misstatements‡ have crept into evolutionary writings regarding the spread of the introduced plants and their rapid "*replacement*" of the indigenous flora. I will state briefly what I believe to be the true state of affairs.

There have been recorded for New Zealand up to the present some 555 species of introduced plants, but less than 180 can be considered common, whilst others are local, rare, or even not truly established as wild plants. Many at first sight appear better suited to the soil and climate than are the indigenous species, and over much of the land they give the characteristic stamp to the vegetation; *but this is only the case where draining, cultivation, constant burning of forest, scrub, and tussock, and the grazing of a multitude of domestic animals have made absolutely new edaphic conditions which approximate to those of Europe*, and where it is no wonder that the European

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* During the discussion following the reading of this paper the expression "extremely small" was criticized as not giving a fair representation of the views of Darwin and his followers. Darwin, however, writes (1889)—p. 45, "Variations, however slight"; p. 58, "any advantage, however slight"; p. 59, "extremely slight modifications"; p. 69, "individual differences, too slight to be appreciated by us." Weismann puts the case more strongly still (1910, p. 25): "For the question is not merely whether finished adaptations have selection value, but whether the first beginnings of these, and whether the small, I might almost say minimal, increments which have led up from these beginnings to the perfect adaptation have also had selection value." Wallace, on the other hand (1889, pp. 126, 127), claims that though Darwin used the word "slight" and "small amount," these terms are "hardly justified," since the variability of many important species is of considerable amount, and may very often be properly described as large.

† The case of Krakatoa, important as it otherwise is, seems to me to have but little bearing on this question, since the distance from the mainland is too trifling.

‡ Wallace (1889, pp. 28, 29) refers to *Trifolium repens* exterminating *Phormium tenax;* excellent pasture destroyed in three years by *Hypochoeris radicata*, which can even drive out white clover; and *Sonchus oleraceus* growing all over the country up to an elevation of 6,000 ft. Kirk (1896, p. 18) not only attributes the "displacement" of *Phormium* to grasses and clovers, but also *Mariscus ustulatus*, and even *Pteridium esculentum* (bracken fern). Further on (p. 19) he states that *Aciphylla Colensoi* is gradually replaced by self-sown pasturage plants. However, he also calls attention to the effect of grazing and trampling by cattle and horses as aiding the plants in their work, which, of course, is a very different matter from the effect of plants alone.

invader can replace the aboriginal.* On the other hand, although this foreign host is present in its millions, and notwithstanding abundant winds and land-birds,† *the indigenous vegetation is still virgin and the introduced plants altogether absent where grazing animals have no access and where fires have never been.* On certain subalpine herb-fields the indigenous form of the dandelion (*Taraxacum officinale* Wigg.) is abundant, and yet the introduced form, with its readily wind-borne fruit, has not gained a foothold, nor even the abundant *Hypochoeris radicata* L., though it may be in thousands on the neighbouring tussock pasture, less than one mile away. On Auckland Island introduced plants occur only in the neighbourhood of the depots for castaways, but on Enderby Island, where there are cattle, they are much more widely spread. Even where the rain forest has been felled or burnt, and cattle, &c., are kept away, it is gradually replaced by indigenous trees and shrubs—*i.e.*, in localities where the rainfall is sufficient.

Some of the indigenous species are quite as aggressive, or even more so, than any of the introduced. In primeval New Zealand each would have its place in the association to which it belonged—there would be no aggression; but when the balance of nature was upset by the fire or cultivation of Maori or European, then the plants best equipped for occupying the new ground become dominant, their "adaptations" for that purpose fortuitously present. The miles on miles of *Leptospermum scoparium* and *Pteridium esculentum* were absent in primitive New Zealand. So, too, the pastures of *Danthonia semiannularis* R. Br.‡ in Marlborough, and the many acres of *Chrysobactron Hookeri* Colenso (Liliac.) in the lower mountain region of Canterbury. *Celmisia spectabilis* Hook. f., an apparently highly specialized herb for alpine fell-field or tussock-steppe conditions, is now on the increase in many montane parts of the Ashburton-Rakaia mountains and valleys, owing to its being able to withstand fire, the buds being protected by a close investment of wet decayed leaf-sheaths.

Nor are all the introduced species aggressive, by any means. Some can barely hold their own; others are limited to certain edaphic conditions. Thus, *Glaucium flavum* Crantz occurs, as yet, only on the coast of Wellington, chiefly in the neighbourhood of Cook Strait. It is confined to gravelly or stony shores, and appears unable to grow on the clay hillside. And yet where the latter is, in one place near Lyall Bay, covered with gravel there is a large colony of the plant, whence none have found their way on to the adjacent hillside. *Lupinus arboreus*, now so common on New Zealand dunes, appears unable to spread beyond the sandy ground.

The often-quoted stories (see footnote, p. 32) of white clover (*Trifolium repens* L.) being able to wipe out *Phormium tenax*, of *Salix babylonica* overcoming the watercress (*Radicula Nasturtium-aquaticum*), of *Hypochoeris*

* New Zealand may be roughly divided into three areas—viz., the cultivated, the pasture lands, and the primitive. It is only in the pasture lands that a real struggle between the introduced and the indigenous plants is taking place, and even there the contest is very unequal, through the grazing, burning, and seed-sowing factors. Many pastures, however, are altogether new associations, as in the case of forest being felled, then burned, and the ground sown with grasses, &c., even before the ashes of the trees are cooled, so that at once there is a foreign pasture brought into existence and subject to an entirely new set of conditions from that which governed the forest. This is certainly *not* biological "replacement."

† Introduced, not native, birds.

‡ The species may be *D. pilosa*, but I have no specimens for identification

radicata displacing every other plant of excellent pastures in Nelson, are without foundation. *P. tenax* has certainly been eradicated in many places, and perhaps, in a sense, replaced by white clover, *but not until fire and feeding of stock had killed the plant.*

The great screes, called locally "shingle-slips," which are such a characteristic feature of mountain scenery in much of the South Island, possess a most scanty and scattered vegetation, made up of some twenty-five highly specialized species belonging to thirteen families, of which twenty species occur in no other formation. Here the struggle between the individuals is nil, but that with the environment, especially the unstable substratum, is most severe. I know of no instance where a non-indigenous plant has established itself on a true alpine shingle-slip.* In such a station no plant could gain a footing unless provided *beforehand* with some special "adaptations": fitting it for the severe conditions. *The shingle-slip association, moreover, is neither the climax of a succession nor is it part of such; it is an association complete in itself, and connected with no other.* Of a number of plants germinating by chance on a shingle-slip, the seedling which possessed a slightly more xerophytic structure than its fellows would be none the better, but would perish equally. Granting that natural selection can intensify† characters by slow degrees, the conditions would select too rigorously—there would be no survivors. It is almost equally difficult to see how epharmony could work, either. A plant to gain a shingle-slip must come from some specially xerophytic station. This is shown by the presence of *Veronica epacridea* Hook. f. and *V. tetrasticha* Hook. f., rock-xerophytes. Perhaps the true shingle-slip plant *Craspedia alpina* Backh., a summer-green herb with leaves in rosettes and thickly covered with a deep snow-white wool, also arrived from some other formation, and its abundant wool and deciduous leaves have arisen epharmonically. The dimorphic succulent *Claytonia australasica* Hook. f. also occurs elsewhere, one form being found in cold streams and damp gravel. Its rapid response to a xerophytic stimulus accounts for its presence.

The seedlings of the true shingle-slip plants are, so far as they have been studied, strongly xerophytic at an early age. Thus an examination of a seedling of *Stellaria Roughii* Hook. f. raised by me under mesophytic conditions showed, "in the elastic stem, pale glaucous-green leaves, and early succulence of the seedling, how hereditary are the most striking peculiarities of shingle-slip plants" (Cockayne, 1901, pp. 267–69).

An interesting point is the occurrence of two distinct species of *Cotula*, or varieties of one species, it matters not, which are epharmonically equivalent. Taxonomically they differ in colour of florets, size of flower-head, and size of involucre as compared with head. Accumulative selection could do nothing here; both plants thrive equally well, and there is no competition except with the environment. Mutation alone can explain this remarkable case, or some cause unknown. Another somewhat similar example is *Notothlaspi rosulatum* Hook. f. and *N. australe* Hook. f. and its var. *stellatum* T. Kirk. *Anisotome carnosula* is in appearance exactly like *A. diversifolia* Cockayne, but there are technical differences

* Introduced plants occur at times on small screes at base of rocks, and on river-terrace scree in the lower mountain belt.

† Weismann writes (1910, p. 61), "How often has the senseless objection being urged against selection that it can create nothing; it can only reject. . . . But in rejecting one thing it preserves another, intensifies it, combines it, and in this way creates what was new."

in the umbel and the involucral bracts. *A. diversifolia* has been found so far on only one mountain on which *A. carnosula* is not known to occur; but the species are so much alike that they could only be recognized when in bloom and examined closely.

To trace the evolution of the shingle-slip plants it seems clear that one must go back to the origin of the shingle-slips themselves from their small beginnings before the eastern peaks of the Southern Alps were disintegrated into rounded summits. If for any reason the climate were wetter,* there would be a similar condition of affairs to what governs the shingle-slips of Westland to-day where true shingle-slip species are absent. On the embryonic debris slopes many plants could settle down, and to the believer in natural selection nothing could appear more probable than for these to have been gradually changed in accordance with the slowly changing environment, species after species going to the wall, until only the few highly differentiated should remain. Even these are absent over wide areas of the most extensive and unstable of these alpine deserts.

An exactly similar argument to the above would apply to water formations, especially as there are cases where true water-plants — *e.g.*, *Potamogeton Cheesemanii* Bennett—flourish in situations where they are quite uncovered for considerable periods. Even for unstable dunes, where there is certainly no struggle between plant and plant, and where no non-sand-binding form could possibly become established, a similar argument would apply, since all degrees of sand-movement exist in a dune-area. *But in all the above cases we do know that ecological factors can evoke structures such as are essential, and we do not know for a fact that selection can intensify a character beyond a certain limit.* In the tussock-grass *Poa caespitosa* the power to respond to sand-movement is already present, although its adaptations fit it for other conditions; thus it has occupied the recent drifting sands of Central Otago. Cases such as these, of stony debris, water, and dune, should be decided not on preconceived opinions or theories, but on the most reasonable conclusions from the observed facts.

Rock-vegetation, although open, affords plenty of scope for the struggle for existence both between the individuals and with the environment, since, leaving the lithophytes out of the question, the space for rock-crevice plants is very limited.

On the recent *roches moutonnées* alongside the Franz Josef Glacier the occupation of rock is now in progress. The pioneer plant is a dark-coloured species of moss, which when it happens to grow in a crevice forms a soil, an essential for the successful germination of seeds in such a station. The first-comers are all plants of some neighbouring association, mostly xerophytes, some herbs, and other shrubs, or even trees, whose long roots can penetrate into the chinks. Exceptions to this are the filmy fern *Hymenophyllum multifidum* Swz., the epiphytic or rock-dwelling orchid *Earina autumnalis* Hook. f., and *Lycopodium varium* R. Br.; but it must be remembered the atmosphere is nearly always saturated with water-vapour. The above first-comers react one upon another, the most vigorous finally conquering; but this vigour depends rather upon age than on greater

* Speight, in a carefully considered paper (1911), brings forward a good deal of very suggestive evidence as to the probability of a wetter climate on the east than the present one following the steppe climate. The most important fact adduced is the former presence of extensive forests where steppe alone now exists, since such forest could only be established during a period with many rainy days, and no other explanation seems to fit the case.

suitability for the station. At any rate, the chance for natural selection to effect anything here is very remote, although the competition is powerful.

The number of true rock-plants in New Zealand is comparatively small; but, on the other hand, a great many xerophytes, and even mesophytes, are encountered on dry rocks, but the latter are epharmonically modified during their individual development.

Even hygrophytes may gain a footing, as already seen in the case of *Hymenophyllum multifidum*. The most striking and truly amazing case is that of the kidney-fern (*Trichomanes reniforme* Forst. f.) and *Hymenophyllum sanguinolentum* Sw., which grow *in the full blaze of the sun* upon the lava of Rangitoto Island, Auckland Harbour. The fronds of both, as I saw them on a hot summer's day, were dry and curled up so as to appear dead, but Mr. Cheeseman informs me that in winter the kidney-fern covers the rocks with its translucent fronds, and that those of summer are not dead at all. It seems evident that in this case the protoplasm of these ferns must behave similarly to that of many lichens, and this will be an epharmonic adaptation. The question arises, does such a power lie latent in these ferns as normal rain-forest plants, ferns which cannot tolerate a drying wind or a hot sun and dry atmosphere; and, if so, how can it have possibly come about? Probably the porous rock contains a good deal of water, and the air is usually not dry. Although I do not think that any modification through the struggle for existence takes place amongst rock-plants, yet this case shows that one cannot tell but that the most unlikely species might settle in certain stations, and so inaugurate a new line of descent, no matter how the evolution be brought about.

In closed formations the struggle for existence between individuals is very keen. As I write, in my garden, in a bed crowded with indigenous plants, two rapidly growing and far-spreading Chatham Island herbs have encountered, and one (*Pratia arenaria* Hook. f.) is rapidly replacing the other (*Cotula Muelleri* T. Kirk), a happening quite in accordance with the fact that the former plant is one of the most widely spread of the Chatham Island plants. Reduced to its ultimate factors, the struggle is chiefly one for nutriment in its widest sense, as Clements has shown (1905, p. 286); there is little actual destruction of one plant by another, though they function indirectly by cutting off light, using up nutritive salts, &c. In some cases the greater part of the struggle takes place amongst the young plants, and it is on their adaptations, which may differ much from those of the adult, that the establishment of the latter depends. This is specially evident in those heteroblastic species already dealt with which have ecologically different forms in their different stages. In a forest the conditions for the seedling and sapling trees are very different from those to which the adults are exposed. A favourable variation which might preserve a seedling in the struggle with its environment would possibly have little to do with the imperative demands of the adult. Small outward modifications of a very few individuals could hardly be preserved in the dense growth of saplings* in an upland forest of *Nothofagus cliffortioides* Oerst. The chief requisite of success here is rapidity of growth,† a physiological

* The saplings may grow so closely that one can hardly force a passage through them.

† The case described in my little book, "New Zealand Plants and their Story," of a species of *Eucalyptus* overcoming the eminently aggressive *Leptospermum scoparium*, through its more rapid growth, both germinating at the same time, is instructive in this regard

characteristic that, however much intensified, could bring about no specific differences unless correlated with structural change. In point of fact, the deciding factor in the struggle amongst a close-growing mass of these tree seedlings is probably age. Could all commence on exactly the same footing, then the determining factor would be the situation with regard to the food-supply and the illumination, and no slight beneficial modification would count in comparison.

As for the adult forest-trees, each has, as a rule, its own rooting-place, and its death depends chiefly upon its age, partly upon some disease or other, and but little upon the superior adaptations of its neighbour. Its growth-form, certainly, does have something to do with its longevity, as where spreading branches favour the presence of abundant epiphytes, whose weight may lead to damage and permit the attack of fungi.

A mixed rain forest, apart from modifications due to the nature of the topography, might be expected to offer constant conditions extending over a considerable period. But this is not so; topographically similar parts of a forest may show dissimilar undergrowth, the result of conditions which, similar at first, become dissimilar as the vegetation develops. Thus in the Waipoua Kauri Forest, of which I made a special study, a state of change ruled. In one part there was little undergrowth, and in another part such in abundance. This latter, in time, will, through survival of the fittest, change into forest with little undergrowth. These are two climaxes, and are expressions of the light factor, the dense undergrowth denoting the maximum and the final open forest with the close roof the minimum of illumination. Between these two climaxes there are many transitions. Bring in more light still and so increase the xerophily, the hygrophytes will go to the wall, until, with excess of light, a transition forest and finally a *Leptospermum* heath will be established (Cockayne, 1908, p. 30). From the above it follows that, even were natural selection at work amongst the young plants of any species, owing to the varying change of conditions brought about by these plants themselves there would be an insufficient length of time for any more suitable variety to arise, or, if such selection were very rapid, different types would be selected within a quite limited area. The believer in the efficacy of epharmonic variation would say that forest-trees have arisen from shrubs, or *vice versa*, owing to the stimulus of edaphic, climatic, and other factors, and that selection operated by eliminating those individuals which did not respond epharmonically at various stages of the plants' development. And the special evidence put forth would be that many species possess an unfixed epharmonic tree form and shrub form, while it is known that stature and other features can be modified through changes in nutrition. This, after all, is only Darwinian selection plus an assigned cause for rapid and sometimes favourable modification*; but it is far from being neo-Darwinian selection.

VIII. Distribution of Species.

1. *Distribution in General.*

The distribution of species is primarily a matter of epharmony. Such, however, must in certain cases be referred to a state of affairs no longer

* I do not mean to infer that all modification is favourable.

present,* as in various instances of restricted distribution. Heat is a factor of prime importance, and, so, many species have a definite southern or altitudinal limit beyond which they do not extend (*e.g.*, *Agathis*, *Ipomaea*, *Veronica elliptica*, *Knightia*, *Senecio rotundifolius*, &c.). This is not because they *cannot* exist quite well farther to the south, or at a higher altitude, but that on approaching their heat-minimum they cannot compete with the other better epharmonically suited competitors. Further, changes of land-surface have affected distribution in some cases, especially where they have caused permanent or temporary barriers.

The annual number of rainy days is also a most important controlling factor, and one whose effect is more plainly to be seen than that of heat. The densely forested west of the South Island and the sparsely wooded country beyond the average limit of the western rainfall to the east of the main divide stand out in startling contrast. On the west the evergreen canopy tree, and on the east the brown grass tussock, reflect in their respective dominance the prevailing ecological conditions. The slight differences, too, of the closely related *Gaya Lyallii* Hook. f. and *G. ribifolia* Cockayne are excellent examples of quite small but distinctly epharmonic† distinctions influencing distribution.

Wind is another most powerful factor in New Zealand. According to their relative wind-tolerating power do certain shrubs, &c., replace one another on the shores of Paterson's Inlet, Stewart Island, so that the shoreline has become in its vegetation an exact index of the frequency and velocity of the wind. The above steppe district in the centre and east of the South Island is governed quite as much by the wind as by its moderate rainfall.

Quite common plants are extremely rare in certain localities. *Cordyline australis* Hook. f., a tree of physiognomic importance in many parts of both the North and South Islands, occurs in only one locality in Stewart Island. *Leptospermum scoparium*, usually so abundant, is represented by but one or two individuals in the Chatham Islands, where there is the ideal station for it to form a heath.‡ The tree-fern *Hemitelia Smithii* Hook., so abundant in Stewart Island, is confined, so far as known, to one gully in Auckland Island. *Psychrophyton eximium* Beauverd is abundant on low alpine rocks on Mount Torlesse, Canterbury, but is wanting in similar stations on the range on the opposite side of the valley.

In some cases there is evidence that a plant has been much more abundant, but has been replaced by another species. This is true "replacement," and very different from the so-called replacement of indigenous by introduced plants. *Podocarpus spicatus* R. Br. was an important member of the Stewart Island forest, say, five hundred to a thousand years ago. At the present time there remain only a few trees of that species, but it is common to find old trunks of this taxad on which are growing

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* It is plain from the very nature of the case that perfect harmony can never be established between the growth-forms and the habitat, since change, progressive or retrogressive, is a feature of all formations, and growth-forms once epharmonic will persist long after their epharmonic relation is weakened or destroyed.

† *G. Lyallii* has larger, thinner, and much less hairy leaves than the eastern *G. ribifolia*. They have also drip-tips, which are frequently strongly developed. The juvenile forms are somewhat similar in the two trees.

‡ This term "heath" I have used in my writings in default of a better, well knowing the formation is not truly analogous, except after fire, with the heaths of Europe. By the settlers, when full grown, it is known as "manuka" or "tea-tree scrub." At this stage it is rather forest than heath.

full-sized trees of *Weinmannia racemosa* L. f. *Sophora tetraptera* J. Mill. is restricted in Chatham Island to the forest on limestone near the shore of the Te Whanga Lagoon, though elsewhere in New Zealand it can grow abundantly on rock similar to that of the rest of Chatham Island. The accompanying trees are the same in the limestone forest as in forest of the island generally, but it is evident the volcanic rock of the remainder of the island favours the other trees, which do not allow *Sophora* to become established. Or it may be that *Sophora* is a comparatively recent arrival.*

The distribution of certain species shows that epharmony is by no means so complete between plant and habitat in some cases as one might expect; or, in other words, that a plant can live in a position for which it is not perfectly fitted. Thus, Mr. R. G. Robinson, Superintending Nurseryman for the South Island, informs me that the dominant tree of the Tapanui Forest, *Nothofagus Menziesii* Oerst., cannot be grown in the adjacent State nursery, although *N. fusca* Oerst., a comparatively rare plant in that locality, can be grown with extreme ease; and yet I have seen *N. Menziesii* growing quite well on the flanks of Ruapehu as an isolated tree in the open.† The slow growth of many indigenous trees as compared with introduced species is another case in point. On Antipodes Island the plant-associations are *not* distinguished by their different floristic components so much as by the relative abundance of the different species. This word "abundance" shows that *all* are not equally suited for each station, but that if a plant settles down on ground not specially fitted for its requirements it may be able to hold its place, the struggle for existence notwithstanding. So, too, with various stations on the Auckland Islands. A highly specialized species may thrive under conditions that might be deemed impossible. Such a case is the already mentioned hygrophytic almost aquatic *Trichomanes reniforme* on the sun-baked rocks of Rangitoto. Here are a few more examples: *Crassula moschata* Forst., a coastal halophytic herb, is one of the pioneer plants in the heavily manured ground just abandoned by penguins on the Snares Island. *Colobanthus muscoides* Hook. f., an herbaceous dense cushion plant growing normally on coastal rocks, is another early-comer on the above manured ground, but as conditions become favourable for less manure-tolerating plants both are replaced, tussock moor or *Olearia* forest being the climax association. *Metrosideros scandens* Sol., a root-climbing woody forest-liane, grows in some places on rocks close to the sea. *Griselinia lucida* Forst. f., so far as I am aware always either an epiphyte or a rock-plant, can be cultivated with ease as an ordinary garden-shrub.

The presence of closely related species side by side in the same association has a strong bearing on the mutation question, for it is reasonable to suppose with Leavitt (1907, pp. 210–12) that if natural selection, or even epharmony, is responsible for species-making, only one type will be present. As Leavitt writes, "Mutation breaks the species, and momentarily at least must give a polytypic aspect to the group within a specific

* H. H. Travers (1869) was of opinion that this tree was a very recent arrival, especially as an old resident, Mr. Hunt, did not know it, and as he found a seed on the shore of Pitt Island. I have given my reasons for be oving it an ancient constituent of the flora (1902, pp. 270–71), and have seen no reason to change my opinion.

† The case may not be as strong as it appears, since the seedlings are shade-loving, whereas those of *N. fusca* can tolerate far stronger light. There is also a fine tree in the dry Christchurch Domain, where the climate is much more unsuitable for indigenous forest-plants than Tapanui.

area " (*loc. cit.*, p. 211). I cannot go fully into this important matter, but the following are rather striking examples. Many would not consider some of these plants " species," they are so close; but so long as they are distinct entities which reproduce themselves " true " they meet the case as well or better.

Dracophyllum scoparium Hook. f., and another species considered by Cheeseman a form of this species (1909, p. 420) but by Kirk a var. of *D. Urvilleanum*, grow in the scrub of Campbell Islands. *Celmisia vernicosa* Hook. f. and *C. campbellensis* Chapman, a very rare plant, grow side by side in Auckland and Campbell Islands. *Cotula Traillii* T. Kirk, *C. pulchella* T. Kirk, and *C.* (*obscura* T. Kirk) ? grow together on coastal moor near Foveaux Strait. Two " species " of *Acaena* grow side by side on dunes in Southland: the one has more or less erect branches and long-peduncled flowers—it may be a var. of *A. microphylla* Hook. f.; the other is pressed most tightly to the ground, and has almost sessile flowers—it is *A. microphylla* var. *pauciglochidiata* Bitter. Both forms keep their distinctive characters for years when grown in garden-soil; intermediate forms occur amongst the wild plants which may be variants, mutants, or hybrids. *Cotula atrata* Hook. f. and *C. Dendyi* Cockayne sp. ined. occur on the same shingle-slip. Several absolutely distinct forms of *Veronica buxifolia* Benth. grow on the same subalpine herb-field (see Plate II, fig. 1). *Rubus parvus* Buch. and *R. Barkeri* Cockayne are in near proximity in the neighbourhood of Lake Brunner, Westland. *Nothofagus fusca* Oerst. and *N. apiculata* Cockayne grow in company in the forests at Day's Bay (Wellington) and Kaikoura (Marlborough). *Astelia linearis* Hook. f. and *A. subulata* Cheesem. grow side by side on mountain-moors in Auckland and Stewart Islands. *Raoulia australis* Hook. f. and *R. lutescens* Cockayne grow side by side on river-beds of the South Island *Olearia Colensoi* Hook. f. and *O. Traillii* T. Kirk grow mixed together in coastal scrub in Stewart Island. *Cassinia albida* Cockayne, *C. Vauvilliersii* Hook. f., *C. fulvida* Hook. f., and other closely related intermediate forms grow mixed on Mount Fyffe, Seaward Kaikoura Mountains. Two distinct forms of *Cassinia Vauvilliersii* grow just above the forest-line in Auckland Island (see Cockayne 1909A, p. 216). *Cotula lanata* Hook. f., *C. propinqua* Hook. f., and *C. plumosa* Hook. f. grow side by side on the shore of Auckland and Campbell Islands. *Olearia ilicifolia* Hook. f. and *O. mollis* Cockayne grow together in subalpine forest of Westland. Related *Epilobia* grow side by side in many places; some I know come true from seed. *Poa foliosa* Hook. f. and *P. Tennantiana* grow close together in Auckland Island. *Celmisia sessiliflora* Hook. f. and *C. argentea* T. Kirk grow side by side on certain alpine moors of the southern botanical province. *Nothopanax simplex* Seem. and *N. parvum* Cockayne are companion plants in the forest of Stewart Island and Westland. *Carmichaelia Monroi* Hook. f. and a related but more robust species not yet described* grow side by side on steppe and river-bed of the Canterbury Plain and eastern Southern Alps. *Coprosma Petriei* Cheesem. has two forms, one with claret-coloured drupes, and the other with faintly blue drupes; they grow side by side on montane steppe in the South Island. *Coprosma Colensoi* Hook. f. and *C. Banksii* Petrie occur side by side in many forests. *Ranunculus Lyallii* Hook. f. and

* What I take to be this plant received the herbarium name of *C. humilis* from D. Petrie many years ago. It has also been in cultivation along with *C. Monroi* Hook. f. in the Christchurch Domain for a long period.

a plant I considered *R. Traversii*, but which Cheeseman is of opinion is either a hybrid* on a new species, grow together on the Snowcup Mountains, Canterbury. *Ranunculus Buchanani* Hook. f. and the closely related *R. Matthewsii* Cheesem. grow in company on certain alpine herb- or fell-fields of western Otago. *Anisotome pilifera* Cockayne and Laing and its var. *pinnatifidum* T. Kirk grow in company on peat-covered rocks, &c., in the Southern Alps. *Leptospermum ericoides* A. Rich. and *L. lineatum* Cockayne grow together on northern dunes. *Coriaria angustissima* Hook. f., *C. thymifolia* Hunt. & Bonpl., and *C. ruscifolia* L. grow in proximity on Westland river-beds. *Aciphylla Colensoi* Hook. f. var. *conspicua* T. Kirk and the var. *maxima* grow near one another on certain herb-fields or in scrub on the Southern Alps. Two forms of *Ourisia sessiliflora* Hook. f., the one densely villous and with large flowers,† the other a smaller plant in all its parts, the leaves darker green and less hairy and the flowers fewer and smaller, occur on the same herb-field in the Southern Alps. *Pittosporum rigidum* Hook. f. and *P. divaricatum* Cockayne (see Plate I) occur in the same forest-area on the volcanic plateau. *Sophora microphylla* Ait. and *S. prostrata* Buchanan grow side by side in the bed of the River Waimakariri at the lower gorge. Doubtless a number of other examples could be found. The coupled plants are in all cases so closely related that they are considered by most New Zealand botanists either varieties of one species, the type and a variety, or forms not worthy of or that have not yet received a name. They are quite sufficient in number to show that *it is not unusual for closely related hereditary plant entities to exist side by side for considerable periods.*

The occurrence of distinct races of the same species at different points of its area of distribution is known in a few cases. As Leavitt says, such cases do not look like the work of mutation, nor can they be readily correlated with epharmony. The following are two striking examples: *Rubus australis* Forst. f. is a common plant both in forests and the open throughout the North, South, and Stewart Islands. In the northern part of the North Island it has, as a rule, much narrower leaves than in the southern part of its range—so much so that typical plants from the two areas have a very different appearance. The primary seedling-leaves seem to be identical in both forms: these are ovate or ovate-lanceolate, and coarsely toothed; they are soon succeeded by narrow leaves, much resembling those of *R. parvus* Buchanan, even as to their yellowish or slightly brownish marking. Seedlings growing in the forest-shade, and only 2·5–5 cm. tall, bear these narrow juvenile leaves, thus showing the form to be inherited, and not merely an epharmonic sun form. Since heredity is undoubted, the northern form demands a name. *Styphelia fasciculata* (Forst. f.), a heath-like small or tall shrub, extends from the North Cape to Canterbury and Westland. The adult form varies but little throughout its range, but the juvenile of the Auckland district has altogether broader leaves than that of the south. An example of a more local character is that of the mountain-herb *Celmisia coriacea* Hook. f., which from Mount Maungatua and other mountains in that part of Otago can be distinguished at a glance as a cultivated plant from other specimens collected on the

* The occurrence of this plant on Walker's Pass far from *R. Monroi* Hook. f. removes the suspicion of a hybrid origin, which Cheeseman adopted, partly at my own suggestion in the first instance.

† To this plant I gave the MS. name of *O. splendida* some years ago.

actual dividing-range. The lowland form of the plant growing near the sea-cliffs at Charleston, west Nelson, is also distinct in appearance.

2. *Isolation.*

This special form of distribution is considered by some to be of the greatest evolutionary importance. The New Zealand biological area offers many ideal localities for geographical isolation, differing in degree, and it is interesting to see as to how far they afford examples of related species which appear to have either diverged *recently* from a stem form, or one of them to be the actual parent plant.

(a.) *The Kermadec Islands.*

The total number of species of vascular plants is 114, of which twelve are endemic.* These latter, one excepted, are closely related to, and in some instances almost identical with, New Zealand, Polynesian, or Norfolk Island plants.

(b.) *The Three Kings Islands.*

There is strong geological evidence that at no distant date these islands were united to the North Island.† The total number of species of vascular plants is 143, of which five are endemic; with these *Alectryon excelsum* Gaertn. var. *grandis* Cheesem. may be included. *Coprosma macrocarpa* Cheesem., one of the five, is related to *C. grandifolia* Hook. f., and more distantly to *C. robusta*, both of which are present on the island. *Pittosporum Fairchildii* Cheesem. is allied by *P. crassifolium* A. Cunn. and *P. umbellatum* Banks & Sol. *Veronica insularis* Cheesem. is related to *V. diosmaefolia* R. Cunn., a species of the neighbouring mainland, and *Paratrophis Smithii* Cheesem. to *P. opaca* Brit. & Rend., while the fern *Davallia Tasmani* Field is not allied to any New Zealand species. None of the endemic plants, then, except the *Alectryon*, are particularly close to their mainland allies.

(c.) *The North Cape.*

This high promontory was undoubtedly quite recently an island. There are three endemic plants—*Halorrhagis cartilaginea* Cheesem. (a near relative of *H. erecta* Schind.), *Geniostoma ligustrifolium* A. Cunn. var. *crassum* Cheesem.,‡ and *Cassinia amoena* Cheesem. (probably related to *C. Vauvilliersii* Hook. f., but which latter is not found nearer than the volcanic plateau).

(d.) *Islands lying to the Eastward of Auckland.*

Veronica Bollonsii Cockayne, a species closely related to *V. macroura* Hook. f., is endemic on the Poor Knights Islands. *Pittosporum intermedium* T. Kirk, intermediate between *P. tenuifolium* Banks & Sol. and *P. ellipticum* T. Kirk, is found only on Kawau Island; only one plant has been found, and this has been destroyed.§

(e.) *The Chatham Islands.*

The total number of species plus named varieties is 236, of which thirty-one are endemic. The genera *Myosotidium* and *Coxella* are endemic and monotypic. The following is a list of the endemic plants; those related

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* See Oliver, 1910, p. 150.

† See Cheeseman, 1891, pp. 419, 420.

‡ Were not Mr. Cheeseman extremely cautious regarding the "creation" of species, &c., I should suspect this to be simply an unstable xerophytic form not very different from that with thick leaves common on the lava of Rangitoto Island.

§ Cheeseman might consider this a hybrid were it not that *P. ellipticum* is not known either in Kawau or the neighbourhood (1906, p. 54).

more or less closely to New Zealand species are marked with an asterisk: *Adiantum affine* Willd. var. *chathamicum* Field (Filic.), **Poa chathamica* Petrie, *Festuca Coxii* Hack. (Gram.), **Carex appressa* R. Br. var. *sectoides* Kükenth., **Phormium tenax* Forst. var. with broad thin drooping leaves (Liliac.), *Geranium Traversii* Hook. f. and var. *elegans* Cockayne (Geran.), **Linum monogynum* Forst. f. var. *chathamicum* Cockayne (Linac.), **Plagianthus betulinus* A. Cunn. var. *chathamicus* Cockayne (Malvac.), *Aciphylla Traversii* Hook. f., *Coxella Dieffenbachii* Cheesem. (Umbel.), **Corokia macrocarpa* T. Kirk (Cornac.), **Styphelia robusta* (Hook. f.), **Dracophyllum arboreum* Cockayne, **D. paludosum* Cockayne (Epacrid.), **Suttonia Coxii* Cockayne (Myrsinac.), **Gentiana chathamica* Cheesem. (Gentian.), *Veronica Dieffenbachii* Benth., *V. Barkeri* Cockayne, *V. Dorrien-Smithii* Cockayne, *V. chathamica* Buch., **V. gigantea* Cockayne (Scroph.), **Coprosma chathamica* Cockayne (Rubiac.), **Olearia semidentata* Dcne., **O. chathamica* T. Kirk, *O. Traversii* Hook. f., **Cotula Muelleri* T. Kirk, *C. Featherstonii* F. Muell., **Senecio radiolatus* F. Muell., **S. Huntii* F. Muell., **Sonchus grandifolius* T. Kirk (Compos.).

The nineteen "species" marked with an asterisk are closely related to forms found elsewhere in New Zealand, while sixteen of these are very close indeed. *Veronica gigantea* would certainly be considered a variety of *V. salicifolia* Forst. *were it not for its distinct juvenile form, which still persists up to a stature of at least 80 cm.*, and its arboreal habit. It is the only true forest-veronica, and it may be that the juvenile form is a direct adaptation to forest-undergrowth conditions.

(f.) *Stewart Island.*

A number of species have, as yet, been collected only on Stewart Island, but in the face of the fact that year by year shows more of the plants thought to be endemic fairly common on the mainland, &c., it is quite possible that the island contains no endemic species.

(g.) *The Subantarctic Islands of New Zealand.*

There are 195 species and named varieties, of which fifty-one are endemic, nineteen of these being closely related to New Zealand species. No list is given here, as these endemic species are treated of by Cheeseman with considerable detail (1909, pp. 463–66). With regard to special endemism in the various groups, the Auckland Islands have six species, the Campbells four, Antipodes Island four, Macquarie Island three, and the Snares two.

(h.) *Isolation on the Main Islands.*

Endemism is not confined to isolated islands, but the various floral districts contain their peculiar species and forms. The most striking examples are western Nelson and western Otago, with thirty-three and thirty-eight endemic species respectively. The northern part of Auckland (thirteen species), Marlborough (fourteen species), and other localities show a distinct local endemism. It is obvious, then, that a strong endemism can exist apart from such a barrier as a wide stretch of ocean. But figures such as the above are not final; further investigations may decrease or even increase them. Also, it is certain that not *all* the species included have originated in the "isolated" areas; some of the most distinct have probably been much more widely spread, and are "relics" merely.

The continuity of distribution of species of the New Zealand flora varies from those with a fairly continuous distribution to those which occur in only a few localities far distant from one another. Notable examples of extreme discontinuity are: *Danthonia antarctica* Hook. f., common in

Auckland and Campbell Islands, but confined elsewhere to a few rocky points and small islands in the far north of the North Island; *Urtica australis* Hook. f., common in Chatham, Antipodes, and Auckland Islands, but in New Zealand proper occurring only on Dog and Centre Islands, Foveaux Strait; *Drosera pygmaea* D.C., only recorded from near Kaitaia in the extreme north and the Bluff Hill in the extreme south; *Pittosporum obcordatum* Raoul, occurs sparingly near Kaitaia, and Akaroa, Banks Peninsula; *Plagianthus cymosus* T. Kirk, only recorded from Dunedin, Lyttelton, some of the Marlborough Sounds, and Kaitaia; *Suttonia chathamica* Mez, common in the Chatham Islands, and found in two localities in Stewart Island; *Lepyrodia Traversii* F. Muell., common in Chatham Island, and found in certain bogs of the Waikato and at one locality near Kaitaia; *Styphelia Richei* Labill., common in Chatham Island, and found elsewhere only near the North Cape; *Melicytus macrophyllus* A. Cunn., common in certain Auckland forests, but absent elsewhere, except one locality near Dunedin. Other examples of discontinuous distribution, though more connected than the above, include *Elaeocharis sphacelata* R. Br., *Dracophyllum latifolium* A. Cunn., *Clematis afoliata* Buch., *Quintinia acutifolia* T. Kirk, *Celmisia Traversii* Hook. f., *Pseudopanax ferox* T. Kirk, *Carmichaelia gracilis* J. B. Armstg., *Coprosma rubra* Petrie, *Veronica speciosa* R. Cunn., &c. Were there merely one or two cases the discontinuous distribution might be attributed to chance, but as there are numerous cases, and as these gradually merge into examples of greater and greater continuity, it is probable that the species in most cases were at one time more widely spread, and that in the extreme cases as above we are face to face with the phenomenon of a species naturally on the verge of extinction.

IX. Evolution in the Genus Veronica in New Zealand.

The New Zealand flora, as already pointed out, possesses many genera containing very "variable species," which are of much interest for evolutionary studies. Of all such, *Veronica* is the most instructive, illustrating, as it does, the general principles of evolution apart from any theories as to method.

Cheeseman admits eighty-four species, but the view he takes is a most conservative one, and probably without forsaking the ideals of orthodox taxonomy some thirty more species could be conveniently added to the list. Were, however, that school of botany which is dealing with *Rosa*, *Rubus*, *Hieracium*, and *Crataegus* in the Northern Hemisphere to study the New Zealand forms, several hundreds of species would be forthwith "created." Should this ever be done without experimental culture of each proposed form the work will be biologically useless.

The species differ both epharmonically and floristically. The former concerns distinctions between groups of forms rather than between species, while the latter treats of the specific marks.

There are two main classes—the shrubby and the herbaceous—together with the suffruticose. The multitude of forms, with but few exceptions, are connected, and a great number more or less intergrade in a linear series. There is every evidence, then, of descent from a common ancestor, which, considering the genus beyond New Zealand as well as within its confines, would probably be an herbaceous plant with a didymous capsule, such as *V. Chamaedrys* L. Further, the plasticity of many "species" and the astonishing variability suggest that changes of form are, biologically speaking, in rapid progress at the present time.

The New Zealand species, with but few exceptions, reproduce themselves readily and rapidly from seed, can be easily grown from cuttings, and are not restricted to any special soil. Some respond quickly to change of environment. The genus occurs in all parts of the New Zealand region, except Antipodes and Macquarie Islands. It has representatives in almost every plant formation, but there is only one true forest species (*V. gigantea*, of Chatham Island). An analysis of distribution shows that seventeen species are coastal, thirteen do not ascend beyond 300 m. altitude, ten to between 300 m. and 900 m., thirteen to 900 m. and less than 1,200 m., and forty-three to that altitude and upwards, while fifty-two of the ninety-six may be considered strictly mountain species.

Regarding their growth-forms, perhaps six species might be considered *herbaceous;* the remainder are all more or less woody, the great majority being *shrubs*. Beyond New Zealand there is one shrubby *Veronica* in Fuegia and the Falkland Islands, *V. elliptica* Forst. f., identical with or closely related to one or other of that series of forms known as *V. elliptica* in New Zealand, and *V. formosa* R. Br. and *V. densifolia* F. Muell. of Tasmania and south-east Australia respectively.

Leaving the herbaceous cushion plants, formerly referred to the genus *Pygmaea*, on one side for the present, the remainder of the herbaceous and suffruticose veronicas (Division *Euveronica* J. B. Armstg.) are distinguished by their *didymous* capsule. But the shrubby *V. loganioides* J. B. Armstg. has a similar capsule. This plant resembles in many respects a juvenile form of the whipcord section of Division I, *Hebe*. There is another epharmonically similar plant, *V. cassinioides* Hort., which has a capsule of the *Hebe* type, and which represents a fixed juvenile form of a whipcord *Veronica*, such as that fixed or semi-fixed form of *V. tetragona* Hook., which occurs occasionally on the volcanic plateau (see Plate V. fig. 2). Still more is the relation to whipcord veronicas shown in the toothed leaves of reversion shoots. With a broadening of leaf, a not uncommon occurrence, there is a close approach to *V. buxifolia* Benth. In considering the phylogeny of the species of *Veronica* the change from herb to shrub would be epharmonic, as may now be seen in the series of forms from just suffruticose to almost shrubs. In such manner *V. loganioides* might arise, and, the form of capsule changing by mutation, there would be *V. cassinioides*, which on the one hand could develop by way of *V. buxifolia* into the mesophytic species, or through pressing of leaves to the stem, and a certain amount of reduction, into the xerophytic whipcord forms. Of course, I do not imagine these are the actual ancestral species, but it does not seem absurd to take them as approximative to such. Some further details may shed a little light on the matter.

The shrubby veronicas fall into three epharmonic classes, using Cheeseman's synopsis. The first would include from *V. speciosa* R. Cunn. to *V. pimeleoides* Hook. f., the second from *V. Gilliesiana* T. Kirk to *V. uniflora* T. Kirk, and the third from *V. macrantha* Hook. f. to *V. Raoulii* Hook. f. The first class shows a leaf gradually decreasing in size, and varying from the willow form, broader or narrower as the case may be, to the small more or less oblong or ovate leaf of so many of the subalpine species—that is, there is a reduction of leaf-surface in accordance with increase of xerophytic conditions. Where lowland species occupy xerophytic stations large leaves are thickened in texture, as in *V. Dieffenbachii* Benth., *V. speciosa* R. Cunn., and *V. macroura* Hook. f., all plants of coastal rocks; or reduced and thickened, as in *V. chathamica* Buch., another coastal-rock plant; or much

reduced in size, as in *V. diosmaefolia* R. Cunn., a heath-plant—indeed, there are few species whose leaf-form cannot be referred to evident epharmony.

The general habit of the species is often strikingly epharmonic. In point of fact, all branch on the same plan, but density or looseness of branching in its extremes makes very different plants, as in the far-spreading, open, and stragglingly branched *V. Cookianum* Col. and *V. Dieffenbachii* Benth., and the close ball-like *V. buxifolia* var. *odora* T. Kirk, *V. Traversii* Hook. f., and many of the subalpine semi-xerophytic species. Still more xerophytic species have the prostrate form, as *V. chathamica*, a plant of wind-swept and spray-swept coastal rocks, and *V. pinguifolia* Hook. f., in some of its numerous forms, as it hugs dry alpine rocks or the stony surface of fell-field. It is instructive, too, to see how one and the same Linnean species varies in the growth-forms of its components. Thus *V. buxifolia* Benth. may be either a ball-like shrub, a low erect open little-branched shrub, or sparsely branched and prostrate. Its leaves, too, vary from patent to imbricating; while as for small leaf-variations, they are without end. The degree of imbricating of leaves is a striking epharmonic feature in these small-leaved veronicas, and Cheeseman uses it, but in a guarded manner, as an aid to identification. But the truth is, the individuals of a well-defined form vary much in this regard according to their surroundings, while there appears also to be non-epharmonic variation of this character.

A more xerophytic station in general than that of the subalpine species of class 1 is demanded by those of class 2. Here reduction of leaf and imbricating reach their maximum in the whipcord forms. These have fully developed though small leaves as seedlings and on reversion shoots, and are thus united to *Veronica Gilliesiana*, T. Kirk, Hook. f., and others whose leaves are not so much reduced. Classes 1 and 2, as here defined, seem to be connected by *V. buxifolia* Benth., as a study of its seedling form shows.* But this latter is also related to *V. cassinioides* Hort., which, as already shown, is a juvenile or ancestral whipcord *Veronica* which may be linked with suffruticose and herbaceous species by *V. loganioides* J. B. Armstg. The relation, then, if my supposition be accepted, between such a species as *V. buxifolia* or some form such as *V. cassinioides* is so close that favourable epharmonic conditions should convert the one into the other in course of time. The cupressoid growth-form of these whipcord veronicas may easily have appeared epharmonically several times. Each time there would be some slight difference in the form evoked, and thus some of the species of whipcord *Veronica* may have originated independently and not from one ancestral† cupressoid form, and there may have been actual

* Details are given by me (1901, pp. 282–86) under the name *V. odora* Hook. f., which, however, is now known through the researches of Cheeseman (1909) to be distinct from the plant in question, which is *V. buxifolia* Benth. var. *odora* T. Kirk. Pl. 11 in the above paper should be consulted, as it shows the relation in form between the juvenile leaves of *V. buxifolia* var. *odora* and *V. Armstrongii* T. Kirk, a whipcord *Veronica*.

† Regarding polygenetic origins, Chilton wrote (1884, p. 156), "Suppose the marine ancestor of the terrestial *Isopoda* to be widely spread, and to inhabit the shores of, say, New Zealand and England, and that in each case certain animals began gradually to leave the sea and make their home on the land, at first keeping within the range of the spray, as *Ligia* still does, but afterwards leaving the sea altogether, would not the new conditions in which these animals would be placed, being practically the same in both countries, produce in each case the same effect, so that the variations which would be preserved would be the same in the two cases, and hence the animals, although arising independently from the same marine ancestor, might so far resemble one another as to be placed in the same genus or even in the same species?" Guppy (1907) should also be consulted.

polygenetic development of species. This polygenetic origin of form, if not of species, is the more likely, as the form exists in other families, while the distribution of the species shows that, though some are widespread, there are a number of species of restricted distribution—*e.g.*, *V. Langii* Cockayne (Stewart Island), *V. Hectori* Hook. f. (western Otago), *V. propinqua* Cheesem. (Mount Maungatua and some other Otago mountains), *V. salicornioides* Hook. f. (Nelson), *V. Astoni* (Tararua Mountains), *V. tetragona* (volcanic plateau), and others not yet described.

Veronica Haastii Hook. f., *V. epacridea* Hook. f., and *V. Petriei* T. Kirk are not definitely connected with the rest of class 2, and may be considered a side branch, with modified leaves.

Class 3 form a distinct line of descent to itself, and its connection with any other branch of the genus is not clear. Two species are moor-plants, and the remainder rock-plants; their growth-forms are epharmonic. The branched panicle of *V. Hulkeana* F. Muell., *V. Lavaudiana* Raoul, and *V. Raoulii* Hook. f. remove them from the rest of the class. Nevertheless, branching of the inflorescence is merely a question of degree, and occurs at times in various species—*e.g.*, *V. Traversii* Hook. f., where it is unexpected—while in others a similar inflorescence is a specific character (*V. diosmaefolia*, *V. Menziesii* Benth.).

Regarding the herbaceous species, *V. pulvinaris* Benth. & Hook. belonging to *Pygmaea*, their leaves are not arranged quadrifariously. By some they are regarded as forming a distinct section of the genus. At present it is impossible to assign them a place in the direct line of descent. They are cushion plants, and epharmonically similar to *Myosotis pulvinaris* Hook. f.

The suffruticose veronicas (*V. catarractae* Forst. f., *V. Lyallii* Hook. f., and *V. Bidwillii* Hook. f.) are closely related to one another—so closely, indeed, that it is hard to assign limits to any as a Linnean species, and the simplest method from that standpoint would be to unite all three.

X. Concluding Remarks.

The object of this paper is to supply material for consideration by students of evolution culled from a field which, although not altogether neglected, is much less cultivated for the supply of evolutionary pabulum, especially by English writers, than is the wide domain of zoology, whence come the bulk of the facts of so many works on evolution.

Whatever of value there may be in this ecological material lies in the fact that it is drawn from an isolated and virgin vegetation, and one, too, where the grazing animal played a most insignificant part compared with its *rôle* in the Old World.

The details have not been selected to support any particular theory, though, of course, as ecolcgical observations are the basis of the paper, the relation of plant to environment takes the leading place.

By one celebrated school of biologists the ultimate inheritance of characters* evoked by stimuli affecting the body-cells is either considered impossible or an occurrence so rare as to be negligible, while such evidence as I have advanced is looked upon as worthless, or, at best, as quite

* For years Henslow has battled strenuously for the cause of the inheritance of acquired characters, but without receiving the attention his works deserve; in fact, many writers seem acquainted only with his "Origin of Floral Structures," and neglect altogether his much more convincing "Origin of Plant Structures," a work full of suggestive material.

insufficient. But another and equally famous school believe such inheritance to be a more or less frequent occurrence, botanists, as a rule, being more in its favour than are zoologists.

Speaking of theories of evolution generally, there seems good reason to consider that such, if not premature, are chiefly of value as a stimulus to biological research. Our ignorance as to the minute structure, the chemistry, and the physiology of the protoplasm is profound. Nothing is known as yet regarding the actual cause of variation. An epharmonic stimulus could do nothing were it not that the inner constitution of the plant is *already* able to respond—*i.e.*, the "machinery" is there ready to produce the possibly epharmonic variation so soon as it gets the necessary touch.

The construction of elaborate theories is not the method by which progress can be made. Actual experiments in the garden, the laboratory, and the field can alone lead to the truth. Even in taxonomy, only experiment can actually decide as to stable and hereditary forms. But observations from nature are also demanded, and here ecology comes in, with the attempt to make use of the wild-plant world, where there are species in the making, as a source of observation. The duty of the ecologist is the collecting of facts in as accurate a manner as possible. The study of epharmony in its manifold phases is urgently required. Its vigorous prosecution should yield a rich harvest of observations, to be examined in the light of experimental evolution.

XI. Literature cited.*

Armstrong, J. B. 1881. "A Synopsis of the New Zealand Species of *Veronica* Linn., with Notes on New Species." Trans. N.Z. Inst., vol. 13, p. 344.

Balfour, I. B. 1879. "The Collections from Rodriquez—Botany." Phil. Trans. R.S., vol. 168, p. 302.

Bitter, G. 1911. "Die Gattung *Acaena*." Stuttgart.

Blaringhem, L. 1907. "Mutation et Traumatisme." Paris.

Buchanan, J. 1870. Introductory Remarks to "List of Plants found in the Northern District of the Province of Auckland." Trans. N.Z. Inst., vol. 2, p. 239.

——— 1871. "On some New Species and Varieties of New Zealand Plants." Trans. N.Z. Inst., vol. 3, p. 208.

Burns, G. P. 1911. "Edaphic Conditions in Peat Bogs of Southern Michigan." Bot. Gaz., vol. 52, p. 105.

Cheeseman, T. F. 1891. "Further Notes on the Three Kings Islands." Trans. N.Z. Inst., vol. 23, p. 408.

——— 1906. "Manual of the New Zealand Flora." Wellington.

——— 1907. "Contributions to a Fuller Knowledge of the Flora of New Zealand." Trans. N.Z. Inst., vol. 39, p. 439.

——— 1908. *Ibid.*, No. 2. Trans. N.Z. Inst., vol. 40, p. 270.

——— 1909. "On the Systematic Botany of the Islands to the South of New Zealand." The Subant. Islands of N.Z., vol. 2, p. 389.

Chilton, C. 1884. "The Distribution of Terrestial *Crustacea*." N.Z. Journ. Sci., vol. 2, p. 154.

Clements, F. E. 1905. "Research Methods in Ecology." Nebraska.

* Works consulted but not referred to in the text are not included, except in a few instances.

Cockayne, L. 1901. "An Inquiry into the Seedling Forms of New Zealand Phanerogams and their Development, Part IV." Trans. N.Z. Inst., vol. 33, p. 265.
——— 1902. "A Short Account of the Plant Covering of Chatham Island." Trans. N.Z. Inst., vol. 34, p. 243.
——— 1904. "A Botanical Excursion during Midwinter to the Southern Islands of New Zealand." Trans. N.Z. Inst., vol. 36, p. 225.
——— 1907. "Note on the Behaviour in Cultivation of a Chatham Island Form of *Coprosma propinqua*." Trans. N.Z. Inst., vol. 39, p. 378.
——— 1907A. "On the Sudden Appearance of a New Character in an Individual of *Leptospermum scoparium*." New Phytol., vol. 6, p. 43.
——— 1908. "Report on a Botanical Survey of the Waipoua Kauri Forest." Wellington.
——— 1909. "Report on a Botanical Survey of Stewart Island." Wellington.
——— 1909A. The Ecological Botany of the Subantarctic Islands of New Zealand." The Subant. Islands of N.Z., vol. 1, p. 182.
——— 1910. "On a Non-flowering New Zealand Species of *Rubus*." Trans. N.Z. Inst., vol. 42, p. 325.
——— 1911. "On the Peopling by Plants of the Subalpine River-bed of the Rakaia (Southern Alps of New Zealand)." Trans. Bot. Soc. Edinb., vol. 24, p. 104.
Cook, O. F. 1907. "Aspects of Kinetic Evolution." Proc. Wash. Acad. Sci., vol. 8, p. 197.
Costantin, J. 1898. "Les Vegetaux et les Milieux Cosmiques." Paris.
Cross, B. D. 1910. "Observations on some New Zealand Halophytes." Trans. N.Z. Inst., vol. 42, p. 545.
Darwin, C. 1899. "The Origin of Species." London. (6th ed.)
——— 1905. "The Variation of Animals and Plants under Domestication." (Popular edition, edited by Francis Darwin.)
Darwin, F. 1908. Presidential Address. Rep. Brit. Assoc.
Dendy, A. 1902. "The Chatham Islands: a Study in Biology." Mem. and Proc. Manch. Lit. and Phil. Soc., vol. 46, pt. 5.
——— 1903. "The Nature of Heredity." Rep. S.Af. A.A.S., vol. 1.
Diels, L. 1906. "Jugendformen und Blütenreife im Pflanzenreich." Berlin.
Goebel, K. 1889–93. "Pflanzenbiologische Schilderungen." Marburg.
——— 1900–5. "Organography of Plants." Oxford.
——— 1908. "Einleitung in die Experimentelle der Pflanzen." Leipzig and Berlin.
Griffen, E. M. 1908. "The Development of some New Zealand Conifer Leaves with Regard to Transfusion Tissue and to Adaptation to Environment." Trans. N.Z. Inst., vol. 40, p. 43.
Guppy, H. B. 1907. "Plant-distribution from an Old Standpoint." Author's copy of paper read before the Vict. Inst.
Hall, H. M. 1910. "Studies in Ornamental Trees and Shrubs." Univ. of Cal. Pub. in Bot., vol. 4, p. 1.
Haswell, W. A. 1891. "Recent Biological Theories.' Rep. A.A.A.S., vol. 3, p. 173.
Henslow, G. 1895. "The Origin of Plant Structures." London.
——— 1908. "The Heredity of Acquired Characters in Plants." London.

Hooker, J. D. 1853. "Flora Novae-Zelandiae." Vol. 1. Introductory Essay, p. i.
Kirk, T. 1871. "On the Botany of the Northern Part of the Province of Auckland." Trans. N.Z. Inst., vol. 3, p. 166.
——— 1889. "The Forest Flora of New Zealand." Wellington.
——— 1896. "The Displacement of Species in New Zealand." Trans. N.Z. Inst., vol. 28, p. 1.
Klebs, G. 1903. "Willkürliche Entwickelungsänderungen bei Pflanzen." Jena.
——— 1910. "Influence of Environment on the Forms of Plants." Darwin and Modern Science, p. 223.
Leavitt, G. G. 1907. "The Geographic Distribution of Closely Related Species." Am. Nat., vol. 41, p. 207.
MacDougal, D. T. 1911. "Inheritance of Habitat Effects in Plants." Plant World, vol. 14, p. 53.
Massart, J. 1910. "Esquisse de la Géographie botanique de la Belgique." Bruxelles.
Oliver, R. B. 1910. "The Vegetation of the Kermadec Islands." Trans. N.Z. Inst., vol. 42, p. 118.
Romanes, G. J. 1893–97. "Darwin and After Darwin." London.
Scott-Elliott, G. F. 1910. "The Waning of Weismannism." Journ. R. Hort. Soc., vol. 35, p. 327.
Speight, R. 1911. "The Post-glacial Climate of Canterbury." Trans. N.Z. Inst., vol. 43, p. 408.
Thomson, G. M. 1901. "Plant-acclimatization in New Zealand." Trans. N.Z. Inst., vol. 33, p. 313. (Contains various supplementary notes by D. Petrie.)
Travers, H. H. 1869. "On the Chatham Islands." Trans. N.Z. Inst., vol. 1, p. 173.
Travers, W. T. L. 1870. "On the Changes effected in the Natural Features of a New Country by the Introduction of Civilized Races." Trans. N.Z. Inst., vol. 2, p. 299.
Vries, H. de. 1901–3. "Die Mutationstheorie." Leipzig.
——— 1905. "Species and Varieties, their Origin by Mutation." Chicago.
Wallace, A. R. 1889. "Darwinism." London.
Warming, E. 1909. "Oecology of Plants." Oxford.
Weismann, A. 1910. "The Selection Theory." Darwin and Modern Science, p. 18.
Williams, W. L. 1904. 'Abnormal Growth of a Plant of *Phormium Colensoi*." Trans. N.Z. Inst., vol. 36, p. 333, and pl. 25.

Art. II.—*Some Hitherto-unrecorded Plant-habitats* (VII).

By L. Cockayne, Ph.D., F.L.S.

[*Read before the Philosophical Institute of Canterbury, 4th October, 1911.*]

This paper is divided into three sections, the first containing the usual general plant-habitats, the second devoted to the neighbourhood of the Franz Josef Glacier, and the third to the plants of the Omeroa Saddle.

My list of plants in Dr. J. M. Bell's report on the Franz Josef Glacier is, as is therein indicated, most incomplete. With the addition of the species here published and those recorded only for the Omeroa Saddle the total is increased from 287 to 356, while a fair idea may be gained of the vascular flora of that part of Westland from the sea-shore to an altitude of 1,200 m. Doubtless there are still many mountain species not recorded, since, so far as the higher land was concerned, I was only able to visit the fell-field, &c., on the right-hand side of No-go Creek, where the slopes are very steep and much broken, and the vegetation merely in patches.

The Omeroa Saddle is situated on a spur which is crossed by the bridle-track leading from the Franz Josef to the Fox Glacier. Its altitude is about 330 m. There is a small amount of open boggy ground, but the bulk of the vegetation is forest. The occurrence of certain subalpine shrubs is remarkable for so low an altitude, but it must be borne in mind that every Westland lowland river-bed contains a percentage of plants which are generally to be found only at a higher altitude.

To Messrs. W. Willcox, D. L. Poppelwell, W. Wilson, and C. Foweraker I am much indebted for various specimens mentioned below. Mr. Poppelwell further has sent me full lists of his collections on the Garvie, Eyre, and other mountains, but these are so extensive and important that it is better that he himself should publish them.

I. Species from various Localities.

Alsophila Colensoi Hook. f.

South Island: (1.) Nelson—Forest near Reefton; L. C. (2.) Canterbury—Forest, Makarora Valley; L. C.

Anisotome Haastii (F. Muell.) Cockayne and Laing.

South Island: Canterbury — Herb-field of Mount Ernest, head of Lake Wanaka. The Misses Ewing!

Anisotome intermedia Hook. f.

South Island: (1) Otago—Curio Bay, near Waikawa, on cliff; L. C. (2.) Westland—Big Bay; L. C.

Australina pusilla Gaud.

South Island: Canterbury—Remains of forest near Waimate. C. Foweraker!

Blechnum Banksii (Hook. f.) Mett.

South Island: Westland—Jackson's Bay; Paringa Bay. L. C.

There are no Westland records in Cheeseman's Manual either for this or *B. durum*.

Blechnum durum (Moore) C. Chr.

South Island: Westland—Jackson's Bay; Paringa Bay. L. C.

Carex Buchanani Berggren.

South Island: Canterbury—Canterbury Plain, by side of water-races, almost to sea-level. L. C.

This is an example of an indigenous plant becoming more widely spread through the farming operations of the settler.

Celmisia bellidioides Hook. f.

South Island: Otago—Cecil Peak, Lake Wakatipu. W. Willcox!

Only three habitats are given by Petrie in his "List of the Flowering-plants of Otago" (Trans. N.Z. Inst., vol. 28, p. 559).

Celmisia densiflora Hook. f.

South Island: Canterbury—Mount Studholme, Hunter's Hills. C. Foweraker!

Celmisia mollis Cockayne.

South Island: Nelson—Mountains near Hanmer. W. Willcox!

Celmisia pseudo-Lyallii (Cheesem.) Cockayne.

South Island: Canterbury—Mount Studholme, Hunter's Hills. C. Foweraker!

This is, so far, the most southern record for this species. Mount Studholme is only 1,085 m. high, but it contains, besides the two species already noted, *C. coriacea* Hook. f., *C. Lyallii* Hook. f., and *C. spectabilis* Hook. f.

Celmisia ramulosa Hook. f.

South Island: Otago—Cecil Peak, near summit. W. Willcox!

Celmisia Walkeri T. Kirk.

South Island: Canterbury — Mount Ernest, head of Lake Wanaka. The Misses Ewing!

Corallospartium crassicaule (Hook. f.) J. B. Armstg.

South Island: Otago—Mount Roy, Lake Wanaka; 1,200 m. altitude. L. C.

Coriaria angustissima Hook. f.

South Island: Westland—(1) Subalpine belt of mountains bounding Taramakau and Otira Valleys; (2) river-bed of Otira, at 300 m. altitude, in company with the two other species, but much less abundant. L. C.

Dacrydium laxifolium Hook. f.

South Island: Otago—Near Curio Bay, Waikawa, within a metre or two of sea-level, in *Sphagnum* bog. L. C.

Dracophyllum virgatum (Cheesem.) Cockayne sp. nov. = *D. uniflorum* Hook. f. var. *virgatum* Cheesem. in "Manual of the New Zealand Flora," p. 427 (1906).

South Island: Westland—Swamp near Lake Brunner. L. C.

Fuchsia Colensoi Hook. f.

South Island: Westland—Near Lake Ianthe. L. C.

F. Colensoi appears to be quite an uncommon species in Westland. For other stations, see II below.

Gahnia rigida T. Kirk.

South Island: Westland—What I take to be this species is common as far south as the Waiho River. L. C.

Gunnera dentata T. Kirk.

South Island: Canterbury—River-bed of River Makarora, head of Lake Wanaka. L. C.

Korthalsella Lindsayi (Oliver) Engler.

South Island: Otago—Crescent Island, Lake Wanaka; parasitic on *Pseudopanax ferox*. L. C.

Leptolepia novae-zelandiae (Col.) Kuhn.

Stewart Island—In rimu-kamahi forest. R. B. Oliver!

Libocedrus Bidwillii Hook. f.

South Island: Westland—One of the members of the low river-bed forest in the Otira Valley. L. C.

The most important trees of this association are *Phyllocladus alpinus* Hook. f., *Podocarpus Hallii* T. Kirk, and *Pseudopanax crassifolium* Seem.

Lycopodium fastigiatum R. Br.

South Island: Westland—Otira Valley, on old river-bed. L. C.

Mazus radicans (Hook. f.) Cheesem.

South Island: Westland — A characteristic plant of lowland and montane river-beds. L. C.

Myosotis Goyeni Petrie.

South Island: Otago—Mount Roy, Lake Wanaka, on dry rock-face, at altitude of 450 m. L. C.

Nothofagus Menziesii (Hook. f.) Oerst.

South Island: Canterbury—Valley of the Makarora, forming a pure forest. L. C.

Olearia Haastii Hook. f.

South Island: (1.) Westland—Otira Gorge, in subalpine scrub; only one plant noted. (2.) Canterbury—Bank of Sloven's Creek, Waimakariri basin. L. C.

O. Haastii, although evidently widely spread, is a rare species, having been recorded from seven localities only, including the above.

Pennantia corymbosa Forst.

South Island: Canterbury—Makarora Valley. L. C.

Pittosporum divaricatum Cockayne sp. nov. ined.

South Island: Westland—Otira Valley, in low forest. L. C.

This attains considerable dimensions. One example was 2·5 m. tall, and had a trunk 12·5 cm. in diameter. I am not sure but that the Westland form is distinct from that of the steppe climate of Canterbury. The seedling leaves are more deeply cut (see Plate VIII, Article I, in this volume).

Poa imbecilla Forst. f.

Stewart Island—R. B. Oliver!

Podocarpus spicatus R. Br.

South Island: Canterbury—Makarora Valley; formerly common in lowland forest. L. C.

Pseudopanax ferox T. Kirk.

South Island: Otago—Crescent Island, Lake Wanaka, on rocky slope. L. C.

Both old and young trees are plentiful.

Rubus cissoides A. Cunn. var. pauperatus T. Kirk.

South Island: Otago—Crescent Island, Lake Wanaka. L. C.

Schoenus pauciflorus Hook. f.

South Island: Canterbury—Kaiapoi Island; Canterbury Plain, almost at sea-level. L. C.

Trichomanes Colensoi Hook. f.

South Island: (1.) Westland—Mount Rangi Taipo, on rock, at about 600 m. altitude; L. C. (2.) Otago—In forest, Anita Bay; L. C.

The number of records for this fern are few, but it is easily overlooked.

Uncinia uncinata (L. f.) Kükenth.

Stewart Island. R. B. Oliver!

Veronica Buchanani Hook. f.

South Island: Otago—Lindis Peak; on summit. L. C.

Veronica dasyphylla T. Kirk.

South Island: Otago—(1.) Cecil Peak; W. Willcox! (2.) Summit of Mount Roy, Lake Wanaka; L. C.

Veronica epacridea Hook. f.

South Island: Otago—Mount Roy, Lake Wanaka; on summit, 1,560 m. altitude. L. C.

Veronica odora Hook. f.

Stewart Island—Exact habitat forgotten, but perhaps Lord's River. D. L. Poppelwell!

Veronica subalpina Cockayne.

South Island: Canterbury—Mount Ernest. The Misses Ewing!

II. Additional Species for the Neighbourhood of the Franz Josef Glacier from the Sea to about 1,200 m. Altitude.

Anisotome pilifera (Hook. f.) Cockayne and Laing.
Subalpine fell-field.

Arundo conspicua Forst. f.

Astelia montana (T. Kirk) Cockayne.
Forest; subalpine fell-field.

Astelia Petriei Cockayne.
Subalpine fell-field, forming extensive patches.

Calamagrostis pilosa (A. Rich.).
Roche moutonnée; moraine; fell-field.

Carex Cockayniana Kükenth.
Forest.

Carex comans Berggren.
River-bed; very common.

Carex dissita Sol.
Near pools of water, at about 210 m. altitude.

Carmichaelia (two species).
River-bed. These species are probably "new." One is prostrate, and the other semi-prostrate. I have only fruiting specimens.

Celmisia petiolata Hook. f.
Subalpine fell-field.

Celmisia Sinclairii Hook. f.
Subalpine fell-field, forming large patches.

Celmisia Walkeri T. Kirk.
On rock where there is covering of soil, forming extensive patches.

Cladium teretifolium R. Br.
Lowland moor.

Claytonia australasica Hook. f.
Small wet stony debris in subalpine belt.

Coprosma brunnea (T. Kirk) Cockayne.
River-bed near terminal face of glacier.

Coprosma ciliata Hook. f.
Subalpine scrub.

Coprosma serrulata Hook. f.
Roche moutonnée, at 650 m.; old moraine, at 900 m.

Coriaria angustissima Hook. f.
Fell-field, at 1,200 m.

Cotula dioica Hook. f.
Salt meadow, Okarito.

Cotula squalida Hook. f.
Old moraine; river-bed and fell-field up to 1,200 m

Dacrydium Colensoi Hook.
Lowland forest.

Dacrydium intermedium T. Kirk.
Lowland forest.

Dracophyllum Kirkii Berggren.
Roche moutonnée.

Dracophyllum Urvilleanum A. Rich. var. montanum Cheesem.
Roche moutonnée.

Epilobium chloraefolium Hausskn.
Fell-field.

Epilobium microphyllum A. Rich.
River-bed.

Epilobium sp.
This is the western plant included by Cheeseman with *E. gracilipes* T. Kirk (see Manual, p. 181). I hope to publish a description of this species shortly, and point out its distinguishing characters.
Fell-field, 1,200 m.

Euphorbia glauca Forst. f.
Shore, Okarito.

Euphrasia Monroi Hook. f.
Fell-field, 1,200 m.

Fuchsia Colensoi Hook. f.
Near Lake Mapourika.

Gahnia rigida T. Kirk.
Forest; lowland moor.

Gaultheria perplexa T. Kirk.
Old river-bed.

Gentiana sp. (perhaps *G. bellidioides* Hook. f., but not in flower).
Fell-field, at 1,200 m.

Geum parviflorum Sm.
Old moraine; fell-field, at 1,200 m.

Hypolepis millefolium Hook.
Fell-field, at 1,200 m.

Juncus maritimus Lam. var. **australiensis** Buchen.
Salt meadow, Okarito.

Loranthus micranthus Hook. f.
Parasitic on various trees and shrubs.

Mazus radicans (Hook. f.) Cheesem.
On river-beds; abundant.

Metrosideros scandens Sol.
Sea-cliff, Okarito.

Muehlenbeckia axillaris Walp.
River-bed.

Myosotis Forsteri Lehm.
Roche moutonnée.

Myosotis macrantha Hook. f. & Benth.
Fell-field, at 1,200 m.; rare.

Nothopanax anomalum Hook. f.
Forest.

Nothopanax parvum (T. Kirk) Cockayne.
Forest.

Olearia moschata Hook. f.
Subalpine scrub; abundant.

Ourisia caespitosa Hook. f.
Fell-field, up to 1,200 m.; common.

Ourisia macrocarpa Hook. f.
Fell-field, at 1,200 m. and lower; common.

Oxalis magellanica Forst.
Fell-field, at 1,200 m.

Pennantia corymbosa Forst.
River-terrace forest.

Poa Astoni Petrie.
Coastal cliff, Okarito.

Poa pusilla Berggren.
River-bed.

Podocarpus Hallii T. Kirk.
Forest.

Ranunculus Godleyanus Hook. f.

Bed of No-go Creek, at about 1,000 m. altitude.

Ranunculus Lyallii Hook. f.

Fell-field ; abundant from about 900 m. upwards.

Ranunculus lappaceus Sm. var.

Raoulia australis Hook. f.

River-bed.

Raoulia glabra Hook. f.

River-bed.

Rubus parvus Buchanan.

(1) Open ground near Lake Mapourika ; (2) bed of River Omeroa. Both in open and amongst shrubs.

Rubus subpauperatus Cockayne.

Scrub of river-terrace.

Schizeilema Haastii (Hook. f.).

Fell-field, at 1,200 m.

Schizeilema nitens (Petrie).

Wombat Pond, on old moraine.

Senecio Lyallii Hook. f.

Fell-field, at 1,200 m.

Trisetum Youngii Hook. f.

Fell-field, at 1,200 m.

III. List of Species of Omeroa Saddle.

Aristotelia fruticosa Hook. f.
Astelia montana (T. Kirk) Cockayne.
Blechnum capense (L.) Schlecht.
——— fluviatile (R. Br.) Lowe.
——— penna marina (Poir) Kuhn.
Carex Gaudichaudiana Kunth.
——— ternaria Forst. f.
Coprosma cuneata Hook. f.
——— foetidissima Forst.
——— parviflora Hook. f.
——— rugosa Cheesem.
——— species with yellow drupe.
Cordyline indivisa (Forst. f.) Steud.
Dacrydium biforme (Hook.) Pilger.
——— Colensoi Hook.
Danthonia Cunninghamii Hook. f.
——— semiannularis R. Br.

Dicksonia lanata Col.
Dracophyllum longifolium (Forst. f.) R. Br.
——— Traversii Hook. f.
Drimys colorata Raoul.
Elaeocarpus Hookerianus Raoul.
Fuchsia excorticata Linn. f.
Gaultheria antipoda Forst. f.
——— depressa Hook. f.
——— rupestris R. Br.
Gleichenia Cunninghamii Heward.
Griselinia littoralis Raoul.
Hymenophyllum Malingii (Hook.) Mett.
——— multifidum (Forst. f.) Sw.
Hypolepis millefolium Hook.
Leptopteris superba (Col.) Pr.
Libocedrus Bidwillii Hook. f.
Luzuriaga marginata (Banks & Sol.) Benth. & Hook.*
Myrtus pedunculata Hook. f.
Nothopanax anomalum Hook. f.
——— Colensoi (Hook. f.) Seem.
——— parvum (T. Kirk) Cockayne.
——— simplex (Forst. f.) Seem.
Olearia Colensoi Hook. f.
——— ilicifolia Hook. f.
——— lacunosa Hook. f.
——— nitida Hook. f.
Phormium Cookianum Le Jolis.
Phyllocladus alpinus Hook. f.
Pittosporum divaricatum Cockayne.
Podocarpus acutifolius T. Kirk.
Polystichum vestitum (Forst. f.) Pr.
Pratia angulata (Forst. f.) Hook. f.
Rubus australis Forst. f.
Senecio eleagnifolius Hook. f.
Styphelia acerosa Sol.
Suttonia divaricata Hook. f.
Uncinia riparia R. Br. ?
Veronica salicifolia Forst. f.
Viola filicaulis Hook. f.

* I understand from Dr. C. Skottsberg that the New Zealand plant is distinct from that of temperate South America. That being so, the New Zealand species must receive a new name.

Art. III.—*Some Notes on the Botany of the Spenser Mountains, with a List of the Species collected.*

By R. M. Laing, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 1st November, 1911.*]

Route.

In December–January, 1910–11, we arranged a small party* to take pack-horses and ascend the headwaters of the Waiau and the Clarence Rivers. We left Hanmer, and went by way of Jack's Pass and Fowler's Pass to the out-station on the Ada. We camped near the foot of the saddle, and explored the surrounding country botanically. Our next camp was in Glacier Gully, a small tributary of the Waiau, some five miles farther to the east. Thence we crossed Maling's Pass to Lake Tennyson, in the neighbourhood of which several days were spent. Bad weather, unfortunately, prevented the ascent of any of the higher peaks. The highest point attained was probably under 6,000 ft., on Mount Princess. Some of the upper alpine plants may, therefore, have escaped observation. The return to Hanmer was made *via* the Clarence Valley.

Historical.

The Spenser Mountains form a little-known district of the Southern Alps, lying at the headwaters of the Waiau, Clarence, and the Wairau. The district was first explored by Mr. W. T. L. Travers during the end of February and the beginning of March, 1860. An account of this exploration will be found in the Nelson *Examiner* of the 14th March, 1860. During the trip he named "the Spenser Mountains in honour of the poet of that name." The name is now often misspelt "Spencer." Maling's Pass is so designated in honour of Mr. C. Maling, who accompanied Travers, and who had seen the pass on a previous trip with Mr. Domett. Maling's Pass leads from the watershed of the Clarence into that of the Waiau. Tributaries of the Waiau were named by Mr. Travers after his children —the Ada, the Henry, and the Anne. *Celmisia Traversii* was originally discovered on the summit of the mountain between the Ada and the Anne. Other novelties discovered by Travers in the district were *Ranunculus crithmifolius*, *R. Lyallii* var. *Traversii*, *R. Sinclairii*, *Pittosporum patulum*, *Gnaphalium nitidulum*, and *Wahlenbergia cartilaginea*. Of these, *Gnaphalium nitidulum* has not again been found, unless, as appears likely (see subjoined list), it is amongst the specimens collected by us.

Since the time of Travers the district has apparently several times been visited by collectors and botanists. However, there is no published account of its botany, and the only list of species drawn up for it is a short one appearing at the end of an article on the ascent of Mount Franklin by Park (Trans. N.Z. Inst., vol. 18, p. 350). This contains seventy-eight species, identified by Buchanan. Of these, about a fifth were not collected by us,

* The party consisted of Mr. W. W. Rowntree, my brother (Mr. T. M. Laing), Mr. C. E. Foweraker, and myself. My best thanks are due to Mr. Foweraker for much valuable assistance in the field. Without it the work could scarcely have been carried on.

but it has not been thought advisable to include them in our list. Indeed, it appears to us that several of those there recorded are most unlikely inhabitants of the district—*e.g.*, *Dodonaea viscosa*, *Gentiana concinna*, *G. saxosa*, *Dracophyllum Urvilleanum* (typical form), *Veronica odora*, *Ranunculus pinguis*. Various species, also, which we had expected to get were not found by us. Amongst these may be noted *Celmisia Traversii*, of which, however, we saw specimens from Mount Percival, at the back of Hanmer, and *Ranunculus Lyallii*, which we did not see at all, though we were assured that it grows in the district. It is quite clear that neither of these species are common in the Spenser Mountains.

There are several reports on the geology of the district. References to it will be found in Haast's "Report of a Topographical and Geographical Exploration of the Western Districts of the Nelson Province," 1861. He visited the Buller and Grey Valley in 1860, and saw the Spenser Mountains from their western sides. He speaks of "the high mountain-chain, called by my friend Mr. Travers the Spencer [*sic*] Mountains, whose highest peak, clad with eternal snow, rose grandly above the low hills in front of it. I named this mountain, Mount Franklin, in honour of the late Sir John Franklin."

In the "Reports of Geological Explorations during 1888–89" (Wellington, 1890) there is an article by Mr. A. McKay on the "Geology of Marlborough and the Amuri District of Nelson," which describes the geology of the eastern slopes of the Spenser Mountains (throughout the report spelt "Spencer").

Topographical.

The Spenser Mountains are some twenty-five miles in length, and are generally regarded as lying between the saddle of the Ada (3,300 ft.) and Mount Franklin (7,671 ft.). The peaks are of a nearly uniform height of 7,000 ft., with an upward tendency towards Mount Franklin. The height of 10,000 ft. allotted to Mount Franklin by some of the earlier explorers was an error, doubtless due to its extensive snowfields and alpine magnificence. The Waiau, Clarence, and Wairau all converge upon this peak, and, indeed, their chief sources lie upon it. To the south are Mounts Guinevere, Aeneid (7,050 ft.), Princess (6,973 ft.), Una (7,540 ft.), and Faerie Queene (7,332 ft.). The Tennysonian names are due to Governor Weld.* In the valley of the Waiau lies Lake Guyon, and in that of the Clarence Lake Tennyson. Both are glacier lakes, due to the banking-up of the waters by morainic deposits. Indeed, the whole country gives evidence of having at one time been heavily glaciated. The Ada Stream runs through a wide glacial valley, and there has been a large terminal moraine across the Waiau about a mile and a half below its junction with the Ada. The head of the low saddle lies also in a flat open valley, about 200 yards wide, having at its highest portion a *Sphagnum* bog. This valley shows no terracing. Opposite its mouth there are a number of parallel lines extending up to about 800 ft. on the left bank of the Waiau. These are perhaps lines of glacial pressure. Glacier Gully has doubtless at one time carried a secondary glacier, but now it can scarcely be regarded as true to name. It opens out at its head into a large cirque on the flanks of

* "Account by F. A. Weld of an Expedition with a View of Discovering a Direct Route between Nelson and Canterbury" ("Canterbury Provincial Gazette," vol. 2, No. 13, p. 51). Weld's trip was made in 1853.

Mount Una, and the bed of the stream (about 3,300 ft. altitude) contains fragments of melting *névé* about 10 ft. thick. Judging by appearances, this *névé* would scarcely last through the summer. The lowest portion was detached from the rest, and was about 100 yards long and 25 yards wide. It was bisected by the stream. A little clear ice was visible at the foot of the *névé*. A pronounced hanging valley on the right of the stream and the remnants of a lateral moraine showed that at one time a glacier of respectable dimensions had filled the creek-bed. The valley is an open one, about 100 yards wide.

The country becomes progressively drier as we go eastward from the Waiau to the Wairau Valley. There are few shingle-slips to be seen on Mount Faerie Queen, as looked at from the Ada Valley. Those on Mount Una, as viewed from Glacier Valley, are a little more extensive, but in the neighbourhood of Lake Tennyson they become more numerous and occupy a larger area. The Wairau Valley, from a saddle above Lake Tennyson, appeared as dry as the region in the neighbourhood of Mount Arrowsmith. Doubtless the westerly rains pass over the saddle into the fertile Ada Valley and Stanley Vale, but are unable to penetrate to the country at the head-waters of the Wairau.

The greater denudation in the Waiau Valley prevents the accumulation of shingle-slips there.

Vegetation.

In the absence of meteorological statistics, it is, of course, impossible to show directly how climatic conditions are affecting the vegetation, and indirect evidence only is available. The conditions in the district, however, resemble those that prevail in the Mount Arrowsmith region, as the plant formations are very similar, and a large number of species are common to both districts. Indeed, the general description given of the plant formations in the Arrowsmith district* would apply to this with but few modifications. Rock, river-fan, river-bed, tussock steppe, bog, lake, forest, fell-field, and shingle-slip present similar features and similar plant-associations in both districts. Certain subassociations of the Arrowsmith district were, however, not noticed in the Spenser Mountains. Dwarf *Carmichaelias* were observed only in the Waiau River bed near Hanmer, and there only a few plants of an unidentified species. The accompanying species of the Mount Arrowsmith district—*e.g. Veronica pimeleoides* var. *minor* and *Muchlenbeckia ephedroides*—were not observed in the more northern area, nor did we see in the Spenser Mountains any such forest as the subalpine totara forest of the Upper Rakaia Valley. Indeed, forest-trees of any kind, with the exception of species of *Nothofagus*, *Nothopanax*, *Gaya*, and *Pittosporum*, were completely absent from the Spenser Mountains. The complete absence of any of the species forming the usual coastal forests of New Zealand is perhaps the most remarkable feature of the district. The subalpine scrub is also poorly represented both in quantity and number of species. River steppe, fell-field, shingle-slip, and rock occupy nine-tenths of the district. The *Nothofagus* forest was found only in the river-valleys, and decreased in quantity from west to east. Only a few acres are to be seen in the Upper Clarence Valley, close to the sides of Lake Tennyson. The upper portion of the Ada Valley, however, contains considerable quantities of the forest, and has contained more; but some has been destroyed by fire

* Cockayne and Laing, Trans. N.Z. Inst., vol. 43, p. 345.

and some cut out for timber. A fuller description of this forest and of the *Sphagnum* bog on the Ada Saddle are given, as they differ considerably in composition from the similar associations observed in the Arrowsmith district.

Physiognomic Changes.

The district has been in occupation by runholders almost since its discovery, and as a result many changes have been effected in the general composition of its vegetation. On the river-flats of the Ada and Clarence Valleys English pasture grasses have been sown, and flourish luxuriantly, displacing to a large extent the native plant covering. The lower portion of the Ada Valley contains beautiful pasturage of cocksfoot and white clover, with here and there a considerable admixture of Yorkshire fog. Occasional patches of *Acaena microphylla, A. Sanguisorbae, Asperula perpusilla, Oreomyrrhis andicola, Cotula dioica, C. squalida,* and specimens of *Stackhousia minima, Ranunculus foliosus,* &c., occur in the midst of the pasture. In the stonier portions it is crossed by lines and thickets of *Discaria* scrub, which rises to a height of 15 ft. to 20 ft., intermingled with occasional specimens of *Coprosma propinqua* and *Veronica cupressoides.* This pasture in the Ada Valley passes at its upper margin into *Nothofagus* forest. The original tussock steppe and the forest-area has been much altered by burning. Severe burns have evidently taken place from time to time, and much of the southern beech* is second growth, with the stumps of the older and heavier trees still standing above it. Sorrel is rapidly gaining ground in many places, and is even invading the shingle-slips. Above the bush is *Danthonia* steppe, which has also in some places been subjected to severe burning. The fell-fields, too, have suffered occasionally from this cause, and new shingle-slips have sometimes formed where the old vegetation has been burnt out. It is difficult, however, to say whether consolidation from shingle-slip to fell-fields is not taking place at an equal or greater rate in neighbouring localities.

The Nothofagus cliffortioides Forest.

The forest of the Ada Valley may be taken as typical of this association. I therefore transcribe my notes upon it, with a few omissions. The river-flats have to a large extent been denuded of forest, and that on the sides of the valley has been much burnt and run through by stock. At its margin the ground-floor is covered to some extent with introduced herbage ; native plants, however, occur, such as *Brachycome Sinclairii, Erechtites prenanthoides, Hydrocotyle novae-zelandiae.* As we go further in we find a large number of young beeches, showing that the forest tends to replace itself. Amongst them are often plants of *Oreomyrrhis, Asperula perpusilla,* &c., and many introduced weeds. *Elytranthe tetrapetala* is also abundant amongst the foliage of the southern-beech forest. Here the largest beeches have only a diameter of 6 in., and doubtless replace the primeval forest, which has been destroyed by fire perhaps thirty years ago. The forest-floor where otherwise bare is covered with beech-leaves, spread over a rich brown humus, fairly free from stones. There is also abundant upon it *Veronica vernicosa* var. *canterburiensis* (Armstrong). In more open spaces *Epilobium pubens* and *Helichrysum bellidioides* appear. As we go deeper

* I am using, at Dr. Cockayne's suggestion, the term "southern beech" (*Nothofagus*) to distinguish our forests from the beech (*Fagus*) forests of the Northern Hemisphere.

into the forest the introduced grasses disappear, the forest-floor becomes damper, and moss appears on it. The bush is still fairly open; distances of 10 ft. to 12 ft. often occur between neighbouring trees. Here are patches covered with a carpet of moss, with young beeches growing through. *Blechnum penna marina*, *Coprosma ramulosa*, and occasional plants of *C. virescens?* now appear, with here and there a young plant of *Nothopanax arboreum*. Through all this portion of the forest cattle have been running.

In passing into the portions of the forest which stock have not destroyed, the undergrowth becomes denser, but still consists of beeches in all stages of development. *Corysanthes triloba*, *Adenochilus gracilis*, and *Chiloglottis cornuta* are now to be found. As we ascend from the river-flat, which is well covered with soil, the forest now becomes stonier; the trees become larger, but many of the larger ones (1 ft. to 2 ft. in diameter) have fallen from some undetermined cause. About a quarter of a mile from the margin a band of *Nothofagus Menziesii* is found, while occasional plants of *Senecio bellidioides* appear on the mossy floor, *Veronica vernicosa* becomes more abundant, and a few specimens of *Coprosma linariifolia* appear. Here the edge of a bush-creek is fringed with *Muehlenbeckia axillaris*, growing into long overhanging sprays, giving the plant a very different appearance from its river-bed form. *Nothofagus fusca*, in clumps, is found higher up the river-flat; but neither it nor *N. Menziesii* altogether replace the *N. cliffortioides*, which probably forms the greater bulk of the forest on to its upper margin. This, at least, was the case in Glacier Valley, where it passes up into *Gaya Lyallii;* but the upper limit of the forest was not examined in the Ada Valley. This may be placed at 800 ft. to 1,000 ft. above the bed of the valley, and the sides are so steep that they are often swept by avalanches of stones, which carry away the beech-trees. Their place is taken by plants of the shingle-fan, and the beeches grow into this vegetation from the sides, and probably in course of time will reoccupy the whole area.

Sphagnum Bog at the Head of the Ada Saddle.

The upper portion of the Ada Saddle is a flat open valley about 300 yards wide, with English pasturage (cocksfoot, Yorkshire fog, clover, sorrel, musk, &c.) and southern beech (*Nothofagus cliffortioides*) forest of a similar type to that described in the Ada Valley some 500 ft. below. *Aristotelia fruticosa*, *Azorella trifoliolata*, and *Acaena Sanguisorbae* occur on the forest-floor, along with many of the plants already mentioned.

The head of the saddle is occupied by a *Sphagnum* bog about 200 yards square, which divides the eastern and western watersheds. A small pond appears in the centre of the bog. The edges are fringed with *Dracophyllum uniflorum*, *Podocarpus nivalis*, *Phyllocladus alpinus*, and *Dacrydium Bidwillii*. The bog is evidently rising, as in many places the *Dracophyllum* is being buried. The *Sphagnum* is dotted with cushions of *Oreobolus pectinatus* and *O. strictus*, and clumps of *Celmisia longifolia* var. *alpina*. Round the edges are *Ourisia macrophylla*, *Celmisia coriacea* and *C. spectabilis*, *Helichrysum bellidioides*, *Microseris Forsteri*, *Senecio lagopus*, *Schizeilema nitens*, and *Pratia angulata*. Other species growing in some quantity on the bog are *Caladenia bifolia*, *Rostkovia gracilis*, *Elaeocharis Cunninghamii*, *Schoenus pauciflorus*, *Carex stellulata*, *C. Gaudichaudiana*, *Cardamine heterophylla*, *Forstera Bidwillii*, and *Drosera arcturi*.

I append some notes on forms of special interest, and a list of species gathered.*

Floristic Notes.

1. Gunnera densiflora (?) Hook. f.

There occurs in the forest of southern beech on the western side of Lake Tennyson and on the margin of the lake a species of *Gunnera*, which is probably the imperfectly described *G. densiflora* Hook f.† The plant grows in considerable abundance on a sloping bank at the water's edge. It agrees fairly well in character with the description of *G. densiflora*. The following is a fuller description:—

Gunnera sp., with short succulent rhizome, herbaceous, creeping, rooting at the nodes, with rather stout villous stolons, 7 cm. to 10 cm. long. Leaves clustered at the nodes. Petioles stout, with rather short silky hairs, somewhat flattened, 4 cm. to 6 cm. long. Petioles stout, with rather short silky hairs, somewhat flattened, 4 cm. to 6 cm. long, straight or recurved. Blades cordate, reniform to orbicular, 2 cm. to 3 cm. wide, glabrous or with a few white or brown hairs on the margin and midrib, sharply dentate to dentate-sinuate, auricles bent upwards towards the upper surface of the leaf, though not appressed to it, veins distinct, palmate. Flowers monoecious, in simple spikes, which are usually unisexual, but occasionally a few female flowers are found at the base of the male spike. Male spike 4 cm. to 7 cm. long, ascending from the axil of the leaf, the peduncle usually shorter than the fertile portion, and covered with a soft woolly pubescence. Flowers shortly pedicellate, provided with a minute linear acute bract, 2 mm. to 3 mm. long, arising from the base of the pedicel, and 2 minute linear sepals smaller than the bract. Petals 2, linear-spathulate, larger than the bracts, hooded with blackish scarious tips, 3 mm. to 5 mm. long. Stamens 2 or 3, filaments shorter than the anthers, anthers ellipsoid, 2-celled. Female flowers sessile, densely crowded with bract, as in the male, calyx-lobes 2, deltoid, apiculate, petals wanting, fruiting-spike elongating to 3 cm. to 5 cm., and covered with a villous brownish pubescence. Fertile drupes 2 mm. to 3 mm. long, rather sparse, pyriform, sessile or shortly pedicellate, crowned by the persistent calyx-lobes.

Mr. Cheeseman has drawn my attention to the fact that the plant is perhaps identical with Tasmanian *G. cordifolia* Hook f. (Benth., Fl. Austral., 2491; *Milligania cordifolia* Hook. f. in Ic. Plant., t. 299). This is more fully described by Schindler in his monograph on *Gunnera* in the Pflanzenreich. The description in the "Icones Plantarum" is very imperfect, and differs from that given by Schindler in several important points. Schindler, also, has not seen the mature drupes, and his account of them in this key to the species is not consistent with that given in the specific description. Doubtless the identity or otherwise of the two species cannot be determined until a definite description of the fruit of the Tasmanian plant is obtained. If the description of the Tasmanian species in the Pflanzenreich is to be relied on, the drupe is ovoid and costate. The drupe in my plants is pyriform, rounded, and without costae. My description was drawn up on the spot from fresh specimens, of which there was abundance.

* My thanks are due to Dr. Cockayne and Messrs. Cheeseman and Petrie for much kind assistance, freely given, in the identification of the species.

† Handbook N.Z. Flora, p. 68.

The following minor differences appear to exist between the New Zealand and Tasmanian forms: In *G. cordifolia* the petioles are shorter than the lamina, in *G. densiflora* (?) they are longer. The blade in the Tasmanian plant is more triangular and less rounded than in the New Zealand one, much more hairy on the margin, and the stolons have much shorter internodes. The male spikes of the one seem, however, to agree well with those of the other, and the general resemblance is undoubted. It will, however, be better to regard our plant as distinct until better evidence of identity is obtained.

Mr. Cheeseman informs me that my plant is distinct from that collected by Dr. Cockayne on the Craigieburn Mountains, and identified by the Kew authorities as *G. densiflora* Hook. f. I have, unfortunately, seen no specimens of Dr. Cockayne's plant.

I have deposited a specimen in the Canterbury Museum.

2. Anisotome Enysii (T. Kirk) Laing (comb. nov.).

Cockayne and Laing (*loc. cit.*) have restored the genus *Anisotome* for the southern species of *Ligusticum;* hence the necessity for this alteration, and the following.

3. Anisotome Enysii (T. Kirk) Laing (comb. nov.) var. tennysonianum Laing.

Foliis pinnatis, ambitu deltoideo-ovatis, pinnis inferioribus trifoliolatis, foliolis minus argute dentatis minus crassisque, quam in forma typica, latioribus autem rotundioribusque.

I have hesitated whether to describe this plant as a fresh species or only as a variety of *A. Enysii*. I have adopted the latter course, because on examining specimens of *A. Enysii* from Central Otago and Banks Peninsula I find that they differ considerably, and probably contain more than one elementary species. Further, I have not seen any type specimens of *A. Enysii* from Castle Hill, and consequently cannot be sure that any of my species truly represent the original type. Until, therefore, the limits of the species *A. Ensyii* are better defined it will perhaps be safer to include this under it as a variety.

A. Ensyii from the Lyttelton Hills is a dwarf chasmophyte with minute linear involucral bracts, united only at the base, and with well-marked ridges on the fruit. A second form is found growing in the turf on the Akaroa - Flea Bay ridge; the pinnae are more distant, the whole plant is taller and laxer than the Lyttelton one, and the involucral bracts are usually free.

In the plants from Naseby given me by Dr. Petrie the toothing of the leaves is less sharp and less deep than in the other forms, and the terminal segment is broader and rounder, whilst the involucral bracts are usually sheathing, as described by Cheeseman. When such differences as these exist in the forms already grouped under *A. Enysii* it seemed unwise to make a fresh species of this plant, particularly as it was found in only one locality, in the upper river steppe on the western side of Lake Tennyson. Though differing markedly from *A. Enysii* in the form of the leaf, the floral characters present only slight variations. A fuller description is appended.

A. Enysii var. *tennysonianum.*

A small spreading plant 5 cm. to 15 cm. high, with stout tap-root. Leaves subcoriaceous, glaucous, glabrous, aromatic, pinnate, with lower

pinnae ternately divided, upper ternately lobed, the whole leaf deltoid-ovate in outline. Petiole as long or longer than the blade, terete, strait, with short broad membranous sheath, 6 mm. broad at the base. Lower petiolules 10 mm. to 15 mm. long, upper shorter, ultimate divisions broadly cuneate, flabellate, dentate, teeth subacute not piliferous. Flowering-stems, several, compound, much exceeding the leaves. Peduncles with 1 or 2 bracts, the lower, if present, one-third of the distance from the base, usually with 3 linear lobes and a broad clasping base, upper bract set midway on the peduncle and smaller. Umbels compound, primary rays 2–3, with a simple linear bract at the base of each ray. Secondary rays 5–7, somewhat unequal, pedicels rather longer than the fruit, 1·5 mm. to 2·5 mm. Fruit surrounded with an involucre of small linear acute bracts. Head heterogamous, the central florets generally male, the outer hermaphrodite. Calyx of 5 lobes, teeth deltoid, acute, minute. Petals white. Styles subulate, equalling the ovary in length, slightly recurved, fruit ellipsoid, carpels with 5 equal ridges.

On the upper river steppe, Mount Princess, above Lake Tennyson: altitude, about 3,500 ft.

A specimen is deposited in the Canterbury Museum.

4. **Myosotis Laingii** Cheeseman.

A hitherto-undescribed species from Lake Tennyson, now named by Cheeseman.

5. **Haastia pulvinaris** var. **minor** Laing (var. nov.).

In omnibus partibus minor quam typus; rami unacum foliis 6 mm. usque ad 15 mm. lati. Pappi capilli non supra incrassati, magis autem scabridi, pene fimbriati.

Two distinct forms of this species appear on Mount Princess (alt., 5,000 ft. to 6,000 ft.). The smaller form is apparently distinguished by the pappus hairs being scabrid, almost fimbriate at the tips, and not thickened as in the typical form. The tomentum of this variety in the specimens we got is much whiter than that in the normal variety.

A specimen is deposited in the Canterbury Museum.

6. **Clemisia petiolata** Hook. var. **membranacea** Kirk.

Two forms of this variety were observed, one with the leaf nearly glabrous on both surfaces, and the other with margins covered with a fulvous pubescence. The leaves in the glabrous form are often cordate at the base, and are broader and shorter than in the form with marginal pubescence.

Fell-field, Glacier Gully; about 4,000 ft.

7. **Gnaphalium nitidulum** Hook. f.

Specimens of a species of *Gnaphalium* were collected on the upper river steppe of the Clarence Valley, at an altitude between 3,000 ft. and 4,000 ft. It appeared to me to agree fairly well with *G. nitidulum* in its characters, a plant that has not been collected since first obtained by Travers fifty years ago. I sent a specimen of it to Mr. Cheeseman, who thus reports upon it:—

"*No. 1750. Gnaphalium* sp.—The female florets are many times more numerous than the hermaphrodite, and the pappus hairs are very numerous, scabrid at the base, and the achenes are faintly downy. These characters place the plant in the genus *Gnaphalium*. The leaves are about ½ in. long,

linear-oblong, obtuse, lower $\frac{1}{3}$ thin and membranous, upper $\frac{2}{3}$ densely covered with white felted tomentum. The heads are sunk among the uppermost leaves, and are about $\frac{1}{5}$ in. diameter. It matches the description of *G. nitidulum*, except in the size of the heads, which are given as $\frac{1}{2}$ in. broad, on very short slender peduncles. But in the allied *G. Traversii* the involucral scales spread after the fall of the florets, making the heads in that state look very much larger than they do in flower. at which time the scales are erect. Hooker's specimens of *G. nitidulum* were evidently past flower, for he says 'florets not seen.' I think it is very likely to prove to be *G. nitidulum;* but specimens should be sent to Kew for comparison with the type."

I have sent specimens to Kew,* and deposited a fragment in the Canterbury Museum.

LIST OF SPECIES.

PTERIDOPHYTA.

Filices.

Hymenophyllum multifidum (Forst. f.) Sw.
villosum Col.
Cystopteris fragilis (L.) Bernh.
Adiantum diaphanum Blume.
Pteridium aquilinum L. var. *esculentum* Forst. f.
Blechnum capense (L.) Schlecht.
penna marina (Poir.) Kuhn.
Asplenium flabellifolium Cav.
Hookerianum Col.
Polypodium pumilum (J. B. Armstrong) Cockayne.
Ophioglossum lusitanicum L.

Lycopodiaceae.

Lycopodium fastigiatum R. Br.
scariosum Forst.
volubile Forst. f.

SPERMAPHYTA.

Taxaceae.

Podocarpus nivalis Hook.
Dacrydium Bidwillii Hook. f.
Phyllocladus alpinus Hook. f.

Gramineae.

Hierochloe redolens (Forst. f.) R. Br.
Fraseri Hook. f.
Trisetum antarcticum (Forst. f.) Trin.
Youngii Hook. f.
Danthonia Raoulii Steud.
flavescens Hook. f.
australis Buch.
semiannularis R. Br.
Poa Colensoi Hook. f.
Kirkii Buch.
imbecilla Forst. f.
caespitosa Forst. f.

* The Kew authorities now (March, 1912) report the specimen forwarded to be identical with the type of *G. nitidulum*.

Koeleria Kurtzii Hack.
Festuca ovina L. var. *novae-zelandiae* Hack.
Agropyron scabrum (R. Br.) Beauv.

Cyperaceae.

Elaeocharis Cunninghamii Boeck.
Carpha alpina R. Br.
Schoenus pauciflorus Hook. f.
Oreobolus pectinatus Hook. f.
strictus Berggr.
Uncinia uncinata (L. f.) Kükenth.
fusco-vaginata Kükenth.
rubra Boott.
leptostachya Raoul.
Carex stellulata Good.
Gaudichaudiana Kunth.
ternaria Forst. f.
Raoulii Boott.
Petriei Cheesem.
lucida Boott.
testacea Sol. A very aberrant form, or new (D. Petrie).
Sinclairii (?) C. B. Clarke. Immature.
Rostkovia gracilis Hook. f.
Luzula campestris D.C.
Juncus novae-zelandiae Hook. f.

Naiadaceae.

Potamogeton Cheesemanii A. Benn.

Liliaceae.

Astelia montana (T. Kirk) Cockayne.
Phormium Cookianum Le Jolis.
Chrysobactron Hookeri Col.

Orchidaceae.

Thelymitra longifolia Forst. f.
Microtis unifolia (Forst. f.) Reichenb.
Prasophyllum Colensoi Hook. f.
Pterostylis Banksii R. Br.
Caladenia Lyallii Hook. f.
bifolia Hook. f.
Chiloglottis cornuta Hook. f.
Adenochilus gracilis Hook. f.
Corysanthes triloba Hook. f.
Gastrodia Cunninghamii Hook. f.

Fagaceae.

Nothofagus cliffortioides (Hook. f.) Oerst.
fusca (Hook. f.) Oerst.
Menziesii (Hook. f.) Oerst.

Urticaceae.

Urtica incisa Poir.

Loranthaceae.

Elytranthe tetrapetala (Forst. f.) Engl.
flavida (Hook. f.) Engl.

Santalaceae.

Exocarpus Bidwillii Hook. f.

Portulacaceae.

Claytonia australasica Hook. f.
Montia fontana L.

Caryophyllaceae.

Stellaria Roughii Hook. f.
Colobanthus Billardieri Fenzl. var. *alpinus* T. Kirk.
acicularis Hook. f.
Scleranthus biflorus Hook. f.

Ranunculaceae.

Clematis australis T. Kirk.
Ranunculus insignis Hook. f.
Monroi Hook. f.
Monroi Hook. f. var. *dentatus* T. Kirk.
Sinclairii (?) Hook. f. Identification not certain in the absence of flowers and fruit.
sp. Scarcely possible to identify in the absence of flowers and fruit.
hirtus Banks & Sol.
lappaceus Smith.
foliosus T. Kirk.
rivularis Banks & Sol.
Cheesemanii T. Kirk. This is perhaps only a hygrophytic form of *R. foliosus* It is everywhere abundant throughout the district, in pools and slow-running water.

Cruciferae.

Cardamine heterophylla (Forst. f.) Schultz var. *micrantha* Schultz.
heterophylla (Forst. f.) Schultz var. *uniflora* Hook. f.
depressa Hook. f.
fastigiata Hook. f.
Enysii Cheesem.
Notothlaspi rosulatum Hook. f.
australe Hook. f.

Droseraceae.

Drosera arcturi Hook.

Crassulaceae.

Crassula Sieberiana Schultz.

Pittosporaceae.

Pittosporum patulum Hook. f.

Rosaceae.

Rubus australis Forst. f.
schmidelioides A. Cunn. var. *coloratus* T. Kirk.
subpauperatus Cockayne.
parviflorum Smith.
Potentilla anserina L. var. *anserinoides* (Raoul) T. Kirk.
Acaena Sanguisorbae Vahl. var. *pilosa* T. Kirk.
inermis Hook. f.
inermis Hook. f. var. *longiscapa* Bitter.
microphylla Hook. f.
glabra Buch.
adscendens (?) Hook. f. *non* Vahl.

Leguminosae.

Carmichaelia subulata T. Kirk.

Geraniaceae.

Geranium microphyllum Hook. f.
molle L.

Oxalidaceae.

Oxalis corniculata L.
magellanica Forst. f.

Coriariaceae.

Coriaria ruscifolia L.
thymifolia Humb. & Bonp.
angustissima Hook. f.

Stackhousiaceae.

Stackhousia minima Hook. f.

Rhamnaceae.

Discaria toumatou Raoul.

Elaeocarpaceae.

Aristotelia fruticosa Hook. f.

Malvaceae.

Gaya ribifolia (F. Muell.) Cockayne.
Lyallii (Hook. f.) Baker.

Violaceae.

Viola Cunninghamii Hook. f.
Hymenanthera dentata R. Br. var. *angustifolia* Benth.

Thymelaeaceae.

Pimelea Traversii Hook. f.
Lyallii Hook. f.
sericeo-villosa (forma) Hook. f.
Suteri (?) T. Kirk.
Drapetes villosa Cheesem. var. *multiflora* Cheesem.

Myrtaceae.

Leptospermum scoparium Forst.
ericoides A. Rich.

Onagraceae.

Epilobium pallidiflorum Sol.
Billardierianum Ser.
junceum Sol.
pubens A. Rich.
tasmanicum. Haussk.*
pictum Petrie.
tenuipes Hook. f.
alsinoides A. Cunn.
linnaeoides Hook. f.
nummularifolium R. Cunn.
macropus Hook.
gracilipes (?) T. Kirk.
crassum Hook. f.
vernicosum (?) Cheesem.
microphyllum A. Rich.
glabellum Forst.
novae-zelandiae Haussk.
pycnostachyum Haussk. This was collected by Cheeseman at Lake Tennyson, but not collected by us.

Halorrhagaceae.

Halorrhagis depressa Walp.
Gunnera densiflora (?) Hook. f.†
dentata T. Kirk.

Araliaceae.

Nothopanax arboreum (Forst. f.) Seem.

Umbelliferae.

Hydrocotyle novae-zelandiae D. C.
asiatica L.
Schizeilema Roughii (Hook. f.) Domin.
pallidum (T. Kirk) Domin.
trifoliolatum (Hook. f.) Domin.
nitens (Petrie) Domin.
Oreomyrrhis andicola Endl. var. *Colensoi* (Hook. f.) T. Kirk.
andicola Endl. var. *ramosa* (Hook. f.) T. Kirk.
Aciphylla Colensoi Hook. f.
squarrosa Forst.
Monroi Hook. f.
Anisotome Haastii (F. Muell.) Cockayne and Laing.
filifolia (Hook. f.) Cockayne and Laing.
carnosula (Hook. f.) Cockayne and Laing.
aromatica Hook. f.
imbricata (Hook. f.) Laing.
Enysii (T. Kirk) Laing var. *tennysonianium* (Laing).
pilifera (Hook. f.) Cockayne and Laing.
Angelica Gingidium (Forst. f.) Hook. f.
var.‡
decipiens Hook. f.

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* Here used to include the New Zealand forms of the subantarctic *E. confertifolium*.

† *Vide* "Floristic Notes."

‡ A very distinct shingle-slip form (or new species), of which, however, only one specimen was obtained. It is therefore not further described at present.

Cornaceae.

Corokia Cotoneaster Raoul.
Griselinia littoralis Raoul.

Ericaceae.

Gaultheria antipoda Forst. f.
rupestris R. Br.

Epacridaceae.

Pentachondra pumila (Forst. f.) R. Br.
Styphelia acerosa Sol.
Colensoi (Hook. f.) Diels.
fasciculata Forst. f.
Fraseri (A. Cunn.) F. Muell.
Dracophyllum rosmarinifolium (Forst. f.) R. Br.
uniflorum Hook. f.

Gentianaceae.

Gentiana corymbifera T. Kirk.
patula (T. Kirk) Cheesem.
bellidifolia Hook. f.
divisa (T. Kirk) Cheesem. var. *magnifica* T. Kirk.

Borraginaceae.

Myosotis australis R. Br.
Forsteri Lehm.
Traversii Hook. f.
laeta Cheesem.
macrantha Hook. f.
Laingii Cheesem.

Labiatae.

Mentha Cunninghamii (A. Cunn.) Benth.

Scrophularinaceae.

Mazus radicans (Hook. f.) Cheesem.
Veronica subalpina Cockayne.
divergens (?) Cheesem.
salicifolia Forst. f.
vernicosa Hook. f. var. *canterburiensis* Armstr.
buxifolia Benth.
buxifolia Benth. var. *patens* Cheesem.
cupressoides Hook. f.
epacridea Hook. f.
macrantha Hook. f.
Raoulii Hook. f.
pulvinaris Hook. f. & Benth.
linifolia Hook. f.
catarractae Forst. f. var. *lanceolata* Hook. f.
Lyallii Hook. f.
Bidwillii Hook.
decumbens Armstr.
pinguifolia Hook. f.
leiophylla Cheesem.
Gilliesiana T. Kirk.
lycopodioides Hook. f.
Haastii Hook. f.

Ourisia macrophylla Hook. f.
caespitosa Hook. f.
Euphrasia Monroi Hook. f. Thus listed by us, but perhaps *E. Laingii* Petrie.

Lentibulariaceae.

Utricularia novae-zelandiae Hook. f.

Plantaginaceae.

Plantago Raoulii Decne.
Brownii Rapin.
spathulata Hook. f.
lanigera Hook. f.

Rubiaceae.

Coprosma serrulata Hook. f.
rhamnoides A. Cunn.
parviflora Hook. f.
ramulosa Petrie.
virescens (?) Petrie.
brunnea (T. Kirk) Cockayne.
propinqua A. Cunn.
linariifolia Hook. f.
repens Hook. f.
Petriei Cheesem.
Galium tenuicaule A. Cunn.
umbrosum Sol.

Campanulaceae.

Pratia angulata (Forst. f.) Hook. f.
macrodon Hook. f.
Lobelia Roughii Hook. f.
Wahlenbergia cartilaginea Hook. f.

Stylidiaceae.

Phyllachne clavigera F. Muell.
Colensoi Berggr.
Forstera Bidwillii Hook. f.

Compositae.

Lagenophora petiolata Hook. f.
Barkeri T. Kirk.
Brachycome pinnata Hook. f.
Thomsoni T. Kirk var. *membranifolia* (?) T. Kirk.
Sinclairii Hook. f.
Olearia cymbifolia (Hook. f.) Cheesem.
avicenniaefolia Hook. f.
virgata Hook. f. *Forma* with rigid branches and spiny branchlets.
Celmisia Walkeri T. Kirk.
lateralis Buch.
discolor Hook. f.
incana Hook. f.
incana Hook. f. var. *petiolata* T. Kirk.*
petiolata Hook. f. var. *membranacea* T. Kirk.

* *Vide* "Floristic Notes."

Celmisia coriacea Hook. f.
longifolia Cass. Shingle-slip form.
longifolia Cass. var. *alpina* T. Kirk.
laricifolia Hook. f.
bellidioides Hook. f.
viscosa Hook. f.
sessiliflora Hook. f.
spectabilis Hook. f.
Vittadinia australis A. Rich.
Haastia pulvinaris Hook. f.
pulvinaris Hook. f. var. *minor* Laing.*
Gnaphalium Traversii Hook. f. var. *Mackayi* Buch.
nitidulum Hook. f.*
luteo-album L.
collinum Labill.
Raoulia australis Hook. f.
apice-nigra T. Kirk.
tenuicaulis Hook. f.
eximia Hook. f.
Monroi Hook. f.
glabra Hook. f.
grandiflora Hook. f.
bryoides Hook. f.
Helichrysum bellidioides (Forst. f.) Willd.
grandiceps Hook. f.
depressum Hook. f. (Benth. & Hook. f.).
microphyllum Hook. f. (Benth. & Hook. f.).
Selago (Hook. f.) Benth. & Hook.
Cassinia albida (T. Kirk) Cockayne.
fulvida Hook. f.
Craspedia uniflora Forst. f.
alpina Backhouse.
Cotula atrata Hook. f.
atrata. Forma with brown florets.
squalida Hook. f.
dioica Hook. f.
Erechtites prenanthoides D. C.
scaberula Hook. f.
glabrescens T. Kirk.
quadridentata D. C.
Senecio lagopus Raoul.
bellidioides Hook. f.
Lyallii Hook. f.
scorzoneroides Hook. f.
cassinioides Hook. f.
Bidwillii Hook. f.
geminatus T. Kirk.
Microseris Forsteri Hook. f.
Taraxacum glabratum (Forst. f.) Cockayne.

* *Vide* "Floristic Notes."

Art. IV.—*Notes on the Plant Covering of Codfish Island and the Rugged Islands.*

By D. L. Poppelwell.

[*Read before the Otago Institute, 3rd October, 1911.*]

Plate IX.

A. General.

Codfish Island and the Rugged Islands lie off the north-west coast of Stewart Island, and form practically the first barrier met by the south-western storms on their long journey from the Antarctic ice. Unstayed by any break for thousands of miles, these fierce winds sweep across the waters, raising them in angry waves, which, gathering strength and bulk as they travel, ultimately strike these islands with almost irresistible force. The torn and ragged nature of the western coasts speak eloquently of their struggle with these keen winds and storms. The vegetation, too, has through the ages found its place in the struggle for existence both as regards its form and distribution. Dr. Cockayne, in his splendid and exhaustive report on the botany of Stewart Island, has confined himself practically to the mainland, hence a few notes on the flora of these hitherto-unbotanized western ramparts may be interesting.

During Easter, along with a small party of Gore residents, including Messrs. G. J. Anderson, M.P., and R. Fisher, to the latter of whom I am indebted for the photographs here published, I had the good fortune, by the courtesy of the Messrs. Hansen Brothers, to spend the best part of two days at Codfish Island. We left Half-moon Bay by steamer early on Monday, the 17th April, arriving at Sealers' Bay, Codfish Island, at 10.30 a.m., and left again at 3.30 p.m. on the following day. I spent several hours of each day examining the flora, and this paper is based upon observation and notes taken on the spot.

Sealers' Bay about eighty years ago was the site of a sealing settlement; hence, no doubt, the name. The island has long since been deserted, but signs of the old settlement are evident in the clearings in the forest where the huts once stood.

The indigenous species noted numbered 111, belonging to seventy-six genera and thirty-seven orders.

In addition to the indigenous plants, some five naturalized plants were observed, all of which were confined to the open land, and all but one were on the sand-dunes. Perhaps the most abundant of these plants were *Mentha spicata* and *Foeniculum officinale*. Both of these species are used for flavouring sauces, and no doubt were a survival of the old settlement on Codfish Island. Two other plants were *Cryptostemma calendulaceum* and *Cnicus lanceolatus*, the seeds of which were no doubt carried by the wind. The fifth plant was the almost universal *Poa pratensis*, probably introduced by cattle, of which there are a few on the island.

None of these colonists played any dominant part in the plant-association, although *Mentha spicata* held its own with the ferns—*Pteridium aquilinum* and *Lomaria capensis*—in the forest clearings, and *Foeniculum officinale* occupied the position of isolated plants fairly plentifully dotted over the sandhills.

B. Physiography.

The physical features of Codfish Island are much less rugged than those of the shore of the mainland, distant about a mile, where the jagged peaks of the Ruggedy Mountains, rising boldly from the sea, are wild in the extreme. The Rugged Islands form the northern extremity of the range, and partake of the same nature as the main chain. Codfish Island is much more level, and, although about two miles and a half square, no part of it reaches a greater height than about 500 ft. It is forest-clad, except in one or two places where there are small beaches flanked with rocky buttresses and backed by sandhills.

C. Plant-associations.

The vegetation may be fitly dealt with under the several headings of (1) Dunes, (2) Cliffs, (3) Forest.

(1.) *Dunes.*

The shore at Sealers' Bay consists of a sandy beach about half a mile long, terminating in rocky abutments, and having a row of dunes at the back. These dunes are only about 5 chains deep, and rise at their eastern extremity to a height of about 100 ft. They are fairly sheltered by the background of hills, but are exposed to the north and north-west winds. Most of the dunes are fixed, but in parts the sand is still unstable, and towards the east the dunes show evidence, in their greater height and loose appearance, of the effect of the northerly gales. The fore dune, as is usual, is covered with the common sand-binding *Scirpus frondosus*. Behind this, however, a much more complex vegetation is found. The principal plants of the association are *Poa caespitosa*, with an abundance of *Linum monogynum*, *Coprosma acerosa*, and *Pimelea Lyallii;* while dotted throughout these are *Coprosma Colensoi*, *Halorrhagis erecta*, *Euphorbia glauca*, *Scirpus nodosus*, *Senecio lautus*, and *Anisotome intermedia*, with stunted forms of *Myrsine Urvillei*. *Coprosma acerosa* forms in many places an almost continuous mat running flat over the sand, and *Pimelea Lyallii* also takes on a similar habit, except it is climbing through some other plant, when in places it reaches a height of about 4 ft. In damper situations patches of *Hierochloe redolens* and *Hydrocotyle novae-zealandiae* make their appearance, while here and there *Acaena Sanguisorbae*, *Geranium sessiliflorum*, or *Muehlenbeckia complexa* creep over the surface. *Taraxacum officinale* var. *glabratum* and *Erechtites prenanthoides* are also found, with occasional plants of *Veronica elliptica*, *Calystegia Soldanella*, *Lomaria alpina*, *Epilobium nerterioides*, *E. junceum*, *Gnaphalium luteo-album*, and *G. japonicum*. In parts there are many plants of *Craspedia uniflora* var. *robusta*, with the naturalized *Foeniculum officinale*. Where the dunes are absolutely stable the plant covering changes somewhat, and the following typical association is found: *Pteridium aquilinum* in patches, *Poa caespitosa*, *Scirpus nodosus*, *Phormium Cookianum*, *Acaena Sanguisorbae*, *Halorrhagis erecta*, *Veronica elliptica*, with dwarf specimens of *Aristotelia racemosa*, *Dicksonia squarrosa*, *Aspidium vestitum*, *Senecio rotundifolius*, *Astelia nervosa*, *Lomaria capensis*, *Asplenium lucidum*, *Craspedia uniflora*, and *Myrsine Urvillei*. Further back, next the edge of the bush, *Leptospermum scoparium* is found, with here and there small patches of *Lagenophora pumila*, *Gunnera arenaria*, *Sonchus littoralis*, and *Apium prostratum*, and nearer the shore *Rumex neglectus*. *Festuca littoralis* is also fairly

plentiful. At their highest point, where the dune-plants merge into the forest, a heath is found, in which the principal plants are *Lomaria capensis*. *Leptospermum scoparium*, *Muehlenbeckia complexa*, *Lycopodium volubile*, *Gaultheria antipodum* var. *erecta*, *Aristotelia racemosa*, *Carpodetus serratus*, stunted *Weinmannia racemosa*, *Dracophyllum longifolium*, and *Pteridium aquilinum*.

(2.) *Cliffs.*

The association in these situations differs a good deal according to the varying situation, the principal factor in the change being, apparently, wind. Thus, on the exposed points, where the wind has most effect, the principal plant is *Olearia angustifolia*, which is so plentiful in places as to form an almost pure association. Hitherto *Olearia angustifolia* has been reported only from south of Paterson Inlet, on the east coast of Stewart Island, and from the north and south ends of Mason's Bay, on the western coast. The only other localities where it has been observed, apart from the Stewart Island habitats mentioned, are the base of Bluff Hill and Puysegur Point. Not only is it the chief plant of the coastal cliffs of Codfish Island, but it is equally abundant on the seaward base of the Ruggedy Mountains. It forms almost the sole plant covering of the Rugged Islands, where the whole cliff-sides for hundreds of feet are one close mat of stunted weather-beaten plants whose handsome grey-green rosette-like foliage and rounded form stamp the physiognomy of the coast-line in a most marked manner. Dr. Cockayne, in his Stewart Island report, draws attention to the difference in the size of the leaves on different plants of this species, noting two forms of leaf, one about $\frac{3}{4}$ in. to 1 in. in diameter and the other only about $\frac{1}{2}$ in. wide. This same peculiarity was noted by me on bushes growing side by side, and seemed to me to be constant throughout all the leaves of the particular plants, so as almost to suggest varietal distinction. Although *Olearia angustifolia* is the chief plant on cliffs, its predominance is confined to the water's edge, and even there in places it is much mixed with *Senecio rotundifolius*. Speaking generally, *Senecio rotundifolius* increases as a greater height is reached, when *Olearia Colensoi* creeps into the association. The three plants named form the basis of the "*Senecio-Olearia*" association so exhaustively dealt with in Dr. Cockayne's report above mentioned. Growing throughout this association will be found numerous specimens of *Veronica elliptica*, with here and there plants of *Phormium Cookianum*, *Anisotome intermedia*, *Dracophyllum longifolium*, and the shore-ferns *Lomaria dura* and *Asplenium lucidum*. Occasional specimens of *Nothopanax Colensoi* push their green heads through the close-growing scrub. On the rocks at the foot of the cliffs the plants noted were *Crassula moschata*, *Selliera radicans*, *Apium prostratum*, *Myosotis albiflora*, *Scirpus nodosus*, and *Gentiana saxosa*. Where the peat was drier *Gnaphalium trinerve* and *Aspidium vestitum* were also observed.

At the western side of the bay, where the cliffs are more sheltered, a much richer flora was seen. Here, as before, *Olearia angustifolia* and *Senecio rotundifolius* predominated, but *Olearia Colensoi* also appeared in increased numbers, until, as the top of the steep faces was reached, it took the place of the first-named species in the lower formation. Of smaller plants, the principal were *Tetragonia trigyna*, *Anisotome intermedia* (plentiful), *Gentiana saxosa*, *Crassula moschata*, *Poa Astoni* and *P. Colensoi* (on the bare points), *Asplenium lucidum*, *A. obtusatum*, *Mesembryanthemum australe*, *Poa foliosa*, *Lomaria dura*, *Phormium Cookianum*,

Astelia nervosa, and *Stilbocarpa Lyallii*. The last-mentioned was growing in large colonies in several places visible from the sea. Its magnificent leaves, from actual measurement, attained 17 in. in width, and the plants were over 3 ft. tall. Gradually as the rock-face was receded from and the soil became more peaty the scrub became more mixed, until it ultimately merged into forest. An almost similar formation to that described above apparently covers the seaward base of the Ruggedy Mountains, and extends round the north-west coast of the mainland of Stewart Island, although the northern coast seems to want the *Olearia angustifolia* altogether. Of this latter fact I am not certain, as I did not land, and was scarcely close enough inshore to be sure.

The Rugged Islands vegetation may all be described under this heading, as the islands are nothing more than great rocks. The cliff-faces for hundreds of feet are absolutely bare where the full blast of the south-western winds strikes them, but on the northern and eastern sides, where there is a little shelter, the cliffs are covered, as before mentioned, with a close mat of *Olearia angustifolia*. In places *Veronica elliptica* clings to the rocks, with some plants of *Phormium Cookianum* and a few tussock-grasses. An occasional stunted plant of *Metrosideros lucida* appears to maintain a precarious existence on the higher points, with a specimen or two of *Olearia Colensoi*, and probably some *Senecio rotundifolius*. *Anistome intermedia* and some of the smaller plants also appear in the crevices. The dominant feature, however, of these wild and inhospitable rock-faces is *Olearia angustifolia*, which is flattened against the cliffs in small and stunted growth in the stormy area, and in proportion as shelter is found in the nooks it becomes larger, and covers the nakedness of the rocks with a grey-green mantle.

(3.) *The Forest.*

General.

The general aspect of the forest of Codfish Island presents a succession of low ridges of sage-green colour, here and there relieved by darker patches. The exposed points, on the contrary, are of much lighter colour, and when the wind blows are traversed by waves of white by the underside of the leaves being thrown up to sight. The top of the forest proper presents an uneven surface, while that of the exposed points is rounded and smooth on the surface. The dominant colour and uneven surface of the forest are brought about by the superabundance of *Dacrydium cupressinum*, whose tall yellowish-green heads are lifted high above the general level of the forest. The darker patches represent patches of *Metrosideros lucida*, although the lighter-green foliage of *Weinmannia racemosa* is also noticeable. The general forest may be placed under the category of the "*Rimu-Kamahi*," and the more exposed scrub as belonging to the "*Senecio-Olearia*" association of Cockayne's report. Of these divisions, the latter may fairly be called "coastal scrub" and the former the "forest."

* *Coastal Scrub.*

The coastal scrub, as before mentioned, is comprised principally of *Olearia angustifolia*, *Senecio rotundifolius*, and *Olearia Colensoi*, but *Dracophyllum longifolium* also plays a part in it. Close in their foliage, with bent, weird stems and branches, these plants have almost an eerie look, suggestive of some contest with *taniwhas* or other powers of darkness. When, however, after a struggle up the cliff-side, one fairly penetrates

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the scrub, the growth of lovely plant forms which greets the vision is delightful. Here the coast-ferns *Asplenium lucidum* and *Lomaria dura* grow to perfection, while straggling plants of *Phormium Cookianum* are found seemingly somewhat out of their station, which is usually on the coastal cliffs in this region. Great colonies of *Stilbocarpa Lyallii* make their appearance, in places over 3 ft. tall, and with their large reniform leaves suggesting more a tropical growth than a subantarctic one. These latter plants are extremely abundant, the patches in places extending over areas almost a quarter of an acre in extent. As we ascend the hill the association changes. *Asplenium obtusatum* of large dimensions puts in an appearance, along with *Lomaria discolor, Hypolepis tenuifolia, Astelia nervosa, Polypodium Billardieri, Nothopanax Colensoi, Myrsine Urvillei, Coprosma lucida,* and *Dicksonia squarrosa.* Here there is evidence of bird-life. The burrows of the mutton-bird (*Puffinus griseus*) ramify in all directions through the peaty soil, and no doubt affect the plant-association by draining and aerating the soil, while the traffic of the birds themselves must destroy much of the usual undergrowth of the forest. What appeared to be a direct effect of the nests of this petrel was noticeable in one place where a mass of the fern *Lomaria dura* was growing on a heap of humus which was literally honeycombed with burrows. The plants were much larger than usual, and each had a distinct caudex about 12 in. high. At a height of about 250 ft. the forest became more mixed and the undergrowth thicker. *Nertera dichondraefolia* grew on the logs, *Coprosma foetidissima* became common, and *Aspidium vestitum* was added to the former association. At 300 ft. the first *Metrosideros lucida* was encountered and *Dracophyllum* became fairly plentiful. *Nothopanax Edgerleyi* also appeared, and *Myrsine Urvillei, Dicksonia squarrosa,* and *Nothopanax Colensoi* became plentiful. The forest-floor now became covered with *Lomaria capensis* and *Lomaria discolor,* the former especially attaining large dimensions, while the specimens of *Asplenium obtusatum* became larger also. As the top of the ridge was reached *Pittosporum Colensoi* var. *fasciculatum* appeared, with a few plants of *Pteridium aquilinum* and *Rubus australis.* From the top a fine view was obtained to the south-west. Looking over the forest-top, one could see the wind-swept appearance to the south-west, the principal plants being stunted *Metrosideros lucida, Olearia Colensoi, Senecio rotundifolius, Dracophyllum longifolium,* with occasional specimens of *Myrsine Urvillei.* Proceeding along the ridge, *Weinmannia racemosa* became more plentiful, and *Astelia* increased on the forest-floor, along with *Lomaria capensis, Aspidium vestitum, Asplenium bulbiferum,* and *A. obtusatum,* the general depth of the floor-covering being about 4 ft. In hollows where the ground was damper a strong growth of fern-trees (*Dicksonia squarrosa*), with *Nothopanax simplex, Shefflera digitata,* and a broad-leaved species of *Carex ternaria,* was seen, while the logs became covered with *Luzuriaga marginata* and filmy ferns. Here also a few examples of *Podocarpus ferrugineus* were seen, and the tangled stems of the *Rhipogonum scandens* blocked the way, and marked the edge of the forest proper.

*** The "Rimu-Kamahi" Forest.*

Lying to the back of the sandhills, an extensive area of forest of this class is visible. Its outer fringe touches the sand-dunes, and it extends to the highest parts of the island, although the trees become stunted on the heights, and rocks show through the low scrub on the very summit. The lowland bush consists principally of *Griselinia littoralis, Muehlenbeckia*

Fig. 1.—Rugged Islands, from the North.
Codfish Island in distance.

Fig. 2.—View of Northern Aspect of One of Rugged Islands.
Olearia angustifolia in bloom. *Olearia Colensoi* on summit.

Fig. 3.—Rugged Islands (Weather Side).
The exposed parts are practically devoid of plant covering, but crevices full of stunted *Olearia angustifolia*.

complexa, Dicksonia squarrosa, Hemitelia Smithii, Fuschia excorticata, Carpodetus serratus, Weinmannia racemosa, Pittosporum Colensoi, Myrsine Urvillei, Coprosma lucida, Aristotelia racemosa, Schefflera digitata, Pseudopanax crassifolia, and *Rhipogonum scandens.* Some plants of the latter were resplendent with their scarlet drupes. The principal undergrowth consisted of *Lomaria dura, L. lanceolata, Asplenium bulbiferum, Nertera dichondraefolia, Asplenium flaccidum, Polypodium Billardieri, P. australe, Lomaria capensis, Hymenophyllum demissum, H. dilatatum, H. sanguinolentum,* and a species of *Uncinia.* In the damper parts I also noted *Nothopanax Colensoi, Coprosma areolata, Nothopanax Edgerleyi, Alsophila Colensoi, Rubus schmidelioides, Leptospermum scoparium, Myrtus pedunculata, Luzuriaga marginata, Suttonia divaricata, Coprosma Colensoi, C. propinqua, C. rhamnoides,* and *Metrosideros hypericifolia.* After crossing a swampy creek the ground became drier, and *Podocarpus Hallii, P. ferrugineus,* and *Dacrydium cupressinum* joined the association, while the floor became covered with *Lomaria discolor* of immense size. An occasional plant of *Gaultheria antipoda* var. *erecta* was also seen. *Dacrydium cupressinum* here tops the forest, some of the trees being of large size, with fine clean boles, and in many cases no branches for a height of 40 ft. to 50 ft. There was little growth of intermediate height, the principal being *Metrosideros lucida, Nothopanax Colensoi,* and, strange to say, dwarfed specimens of *Sencio rotundifolius;* but the forest-floor was covered by a strong growth of ferns, principally *Lomaria capensis, L. discolor,* and *Polypodium Billardieri. Astelia nervosa* was also plentiful, with quantities of the beautiful filmy ferns. At a height of about 350 ft. a plant of *Styphelia acerosa* was encountered, and from this upwards this plant became fairly plentiful. We ultimately attained a height of about 450 ft. with little change in the association, but *Weinmannia racemosa* became less and *Metrosideros lucida* more plentiful, while the floor-covering alternated between *Lomaria capensis* and *Polypodium Billardieri,* each almost pure. On our return we traversed an exposed open rocky spur, where a small heath made its appearance, the principal plants being *Lomaria capensis, Leptospermum scoparium, Muehlenbeckia complexa, Lycopodium volubile, Gaultheria antipodum,* stunted *Aristotelia racemosa* and *Weinmannia racemosa, Dracophyllum longifolium, Pteris incisa,* and *Pteridium aquilinum.*

D. Conclusion.

There are, on the whole, apparently no very marked differences in the flora of these islands and the adjoining mainland, except, of course, the number of species is limited on the islands. The greatest surprise is perhaps the abundance of *Olearia angustifolia* and the immense size of the ferny undergrowth in the forest proper. The dune association is fairly well that of Mason's Bay, and the mat-like habit of *Pimelea Lyallii, Geranium sessiliflorum,* and *Coprosma acerosa* is precisely that mentioned by Cockayne in his reference to the dune-covering of Port William. The wind factor is the principal one in determining the distribution of the plants, and the "wind-tolerating" theory of Cockayne receives corroboration by the way that *Olearia Colensoi* gives way to *Senecio rotundifolius* and the latter to *Olearia angustifolia,* according to the degree of exposure. Where the wind is sufficiently direct *Olearia angustifolia* itself disappears, leaving practically bare rocks, as on the exposed sides of the Rugged Isles.

LIST OF SPECIES NOTED.

(1.) Pteridophyta.

Hymenophyllaceae.

Hymenophyllum demissum (Forst. f.) Sw. On logs in damp forest plentiful.
dilatatum (Forst. f.) Sw. On logs in damp forest; plentiful.
sanguinolentum (Forst. f.) Sw. On logs in damp forest; plentiful.
tunbridgense (L.) Sm. On logs in damp forest; plentiful

Cyatheaceae.

Dicksonia squarrosa (Forst. f.) Sw. Abundant in forest.
Hemitelia Smithii (Hook. f.) Hook. Forest; not plentiful.
Alsophila Colensoi Hook. f. Forest; rare.

Polypodiaceae.

Polypodium Billardieri R. Br. Plentiful in forest.
australe Mett. Logs in damp forest.
Pteridium aquilinum Kuhn. Heath and stable dunes.
Pteris incisa Thunb. Damp forest.
Aspidium vestitum Swartz. Fairly abundant in forest.
Asplenium bulbiferum Forst. f. Abundant in forest.
flaccidum Forst. f. Abundant in forest.
lucidum Forst. f. Coastal scrub; plentiful.
Lomaria alpina Spreng. Dunes; rare.
dura Moore. Coastal scrub; abundant.
lanceolata Spreng. Forest; abundant.
capensis Willd. Forest; abundant.
discolor Willd. Forest; abundant.
Hypolepis tenuifolia (Forst. f.) Bernh. Forest; abundant.

Lycopodiaceae.

Lycopodium volubile Forst. f. Stony heath; plentiful.

(2.) Spermophyta.

Taxaceae.

Podocarpus Hallii T. Kirk. In forest; common.
ferrugineus Don. In forest; fairly common.
Dacrydium cupressinum Sol. In forest; abundant.

Gramineae.

Hierochloe redolens (Forst. f.) R. Br. Damp dunes.
Poa foliosa Hook. f. Coastal cliffs.
Astoni Petrie. Coastal cliffs.
caespitosa Forst. f. Dunes; abundant.
Colensoi (?) Hook. f. Coastal cliffs; rare.
Festuca littoralis Labill. Dunes; fairly plentiful.

Cyperaceae.

Scirpus nodosus (R. Br.) Rottb. Dunes; plentiful.
frondosus Banks & Sol. Dunes; plentiful.
Uncinia pedicellata Kükenth. Damp forest.
Carex ternaria Forst. f. Wet ground; common.
trifida Cav. Damp ground; open forest.

Liliaceae.

Rhipogonum scandens Forst. Plentiful in forest.
Luzuriaga marginata (Banks & Sol.) Benth. & Hook. f. Logs in forest.
Astelia nervosa Banks & Sol. Dunes, sheltered rocks, forest.
Phormium Cookianum Le Jolis. Coastal rocks and scrub.

Polygonaceae.

Rumex neglectus Kirk. Stony beach.
Muehlenbeckia complexa (A. Cunn.) Meissn. Dunes, damp forest, heath.

Aizoaceae.

Mesembryanthemum australe Sol. Coastal rocks; rare.
Tetragonia trigyna Banks & Sol. Coastal cliffs; rare.

Crassulaceae.

Crassula moschata Forst. f. Coastal rocks.

Saxifragaceae.

Carpodetus serratus Forst. Forest; plentiful.

Pittosporaceae.

Pittosporum tenuifolium Banks & Sol. In forest; rare.
Colensoi var. *fasciculatum* (?) Hook. f. In forest; rare.

Cunoniaceae.

Weinmannia racemosa L. f. Abundant in forest.

Rosaceae.

Rubus australis Forst. f. In damp forest.
schmidelioides A. Cunn. In damp forest.
Acaena Sanguisorbae Vahl. Plentiful on stable dunes.

Geraniaceae.

Geranium sessiliflorum Cav. Dunes; abundant.

Linaceae.

Linum monogynum Forst. f. Dunes; abundant.

Euphorbiaceae.

Euphorbia glauca Forst. f. Dunes; abundant.

Elaeocarpaceae.

Aristotelia racemosa (A. Cunn.) Hook. f. Plentiful; stable dunes and forest-edge.

Thymelaeaceae.

Pimelea Lyallii Hook. f. Dunes; abundant.

Myrtaceae.

Leptospermum scoparium Forst. Edge of forest; plentiful.
Metrosideros lucida (Forst. f.) A. Rich. Abundant in forest.
hypericifolia A. Cunn. Rare in forest.
Myrtus pedunculata Hook. f. Damp forest; rare.

Onagraceae.

Epilobium nerterioides A. Cunn. Dunes; fairly plentiful.
junceum Sol. Dunes; rare.
linnaeoides Hook. f. Dunes; rare.
Fuchsia excorticata L. f. Edge of forest; rare.

Halorrhagaceae.

Halorrhagis erecta (Murr.) Schindler. Dunes; plentiful.
Gunnera arenaria Cheeseman. Dunes.

Araliaceae.

Stilbocarpa Lyallii J. B. Armstrong. Coastal scrub; abundant.
Nothopanax simplex Forst. f. In forest; rare.
Edgerleyi (Hook. f.) Seem. In forest; plentiful.
Colensoi (Hook. f.) Seem. In forest; plentiful.
Schefflera digitata Forst. Damp forest.
Pseudopanax crassifolium (Sol.) C. Koch. Plentiful in forest.

Umbelliferae.

Hydrocotyle novae-zealandiae D. C. Damp dunes.
Apium prostratum Lab. Coastal rocks and dunes.
Anisotome intermedia Hook. f. Coastal rocks; plentiful.

Cornaceae.

Griselinia littoralis Raoul. Forest; not plentiful.

Ericaceae.

Gaultheria antipoda Forst. f. var. *erecta* Cheesm. Forest; comparatively rare.

Epacridaceae.

Styphelia acerosa Sol. In forest; fairly plentiful.
Dracophyllum longifolium (Forst. f.) R. Br. Coastal scrub; abundant.

Myrsinaceae.

Myrsine Urvillei (A. D. C.) Mez. Dunes and forest, coastal scrub.
Suttonia divaricata (A. Cunn.) Hook. f. Damp forest.

Primulaceae.

Samolus repens Forst. var. *procumbens*, R. Knuth. Damp rocky situations near shore.

Gentianaceae.

Gentiana saxosa Forst. f. Coastal rocks; plentiful.

Convolvulaceae.

Calystegia Soldanella (L.) R. Br. Dunes; rare.

Boraginaceae.

Myosotis albiflora (T. Kirk) Cheesem. Rocks near sea.

Scrophularinaceae.

Veronica salicifolia Forst. f. In damp forest.
elliptica Forst. f. Plentiful on coastal rocks.

Rubiaceae.

Coprosma lucida Forst. f. In forest; rare.
areolata Cheesem. Damp forest.
foetidissima Forst. Abundant in forest.
rhamnoides A. Cunn. Plentiful in damp places.
acerosa A. Cunn. Abundant on dunes.
propinqua A. Cunn. Damp forest.
Colensoi Hook. f. Plentiful in damp forest.
Nertera depressa Banks & Sol. On logs in forest.
dichondraefolia (A. Cunn.) Hook. f. On logs in forest.

Goodeniaceae.

Selliera radicans Cav. Damp places on coastal rocks.

Compositae.

Lagenophora pumila (Forst. f.) Cheesem. Stable dunes.
Brachycome Thomsonii T. Kirk. Stable dunes.
Olearia angustifolia Hook. f. Coastal cliffs; abundant.
Colensoi Hook. f. Coastal scrub; abundant.
Gnaphalium trinerve Forst. f. Dunes; plentiful.
luteo-album L. Dunes; plentiful.
japonicum Thunb. Dunes; plentiful.
Craspedia uniflora Forst. f. var. *robusta* Hook. f. Dunes; abundant
Erechtites prenanthoides (A. Rich.) D. C. Dunes; fairly plentiful.
Senecio lautus Forst. f. Dunes; rare.
rotundifolius Hook. f. Coastal scrub; abundant. In forest; rare.
Taraxacum glabratum (Forst. f.) Cockayne. Dunes; fairly plentiful.
Sonchus littoralis (Kirk) Cockayne. Dunes.

LIST OF NATURALIZED PLANTS.

Mentha spicata L. Old clearings.
Foeniculum officinale Hook. f. Sand-dunes.
Cryptostemma calendulaceum R. Br. Sand-dunes.
Cnicus anceolatus Willd. Sand-dunes.
Poa pratensis L. Sand-dunes.

ART. V.—*List of Lichens and Fungi collected in the Kermadec Islands in 1908.*

By W. R. B. OLIVER.

[*Read before the Auckland Institute, 28th November, 1911.*]

THROUGH the kindness of Mr. T. F. Cheeseman, F.L.S., who forwarded the lichens and fungi which I collected on Sunday Island to the Director of the Kew Botanical Gardens, and subsequently furnished me with the names of the species represented, I am able to publish the following list. The fungi were identified by Mr. George Massee, and the lichens by Mr. A. D. Cotton. I know of no record of fungi from the Kermadecs, but in the "Handbook of the New Zealand Flora" (1864–66) Sir J. D. Hooker has recorded two lichens—*Cladonia furcata* and *Lecidea intermixta*—collected by Mr. J. Milne, who visited the group in H.M.S. "Herald" in 1854. Neither of these was collected by me.

Lichens and the fungus *Scorias spongiosa* form a conspicuous feature of the forest on Sunday Island—not by the number of species represented, which are few, but by the abundance of individuals. In the upper wet forest almost every stem of palms and trees is covered with mosses and lichens. Of the latter, those especially common are the foliaceous *Sticta variabilis* and *Leptogium cyanescens*, and the crustaceous *Baeomyces pertenuis* and *Physcia speciosa*. In exposed places, as on ridges and cliffs, where more light penetrates and the wind is more desiccating in its effect, the tree-stems support chiefly the foliaceous *Sticta aurata* and the drooping *Usnea barbata*. On rocks along the sea-coast *Xanthoria parietinia* and *Physcia pulverulenta* are frequent. All the upper branches and twigs of the pohutukawa, especially in the lower dry forest, where they are the dominant trees, are completely clothed with *Scorias spongiosa*, which showers its black spores copiously on the forest below.

LICHENS.

Baeomyces pertenuis Stirb.

Forest; on stems of nikau-palms and trees.

Cladonia capitella Bab.

Forest; among mosses on horizontal branches of trees.

Cladonia Florkeana Fr.

On logs in open.

Cladonia aggregata Eschw.

Forest; on damp ground.

Leptogium cyanescens Kbr.

Forest; on nikau-palm stems, in damp situations. Thallus soft and moist, like an alga, and in dry weather shrivels at the edges.

Sticta variabilis Ach.

Forest; abundant on tree-stems.

Sticta aurata Sm.

Forest; abundant on tree-stems, in dry open situations.

Ramalina fastigiata Ach.

On rocks.

Ramalina farinacea Fr.

Scrub; on tree-stems, in dry open places

Usnea barbata Fr.

Forest; abundant on trees on cliffs and other exposed places.

Xanthoria parietinia T. Fr.

On rocks on sea-coast, from just above high-water mark.

Physcia pulverulenta Fr.

On rocks and trees, in open places.

Physcia speciosa Nyl.

Forest; abundant on palm-stems and trees with smooth bark.

Fungi.

Arcyria punicea Pers.

Trichia fallax Pers.

Forest-floor; on underside of dead leaves of nikau-palms (*Rhopalostylis Baueri*).

Scorias spongiosa Fr.

Forest; on pohutukawa-trees (*Metrosideros villosa*). This fungus completely covers the upper branches of the pohutukawa-trees with a sooty black moss-like growth to a depth of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. It continually sheds its black spores, so that the leaves of all trees and shrubs below are covered with a black dust. Locally it is called "pohutukawa soot," which well expresses its appearance and habit of coating everything with a layer of black.

Auricularia polytricha Mont.

On dead trunks of *Corynocarpus laevigata*.

Fomes zealandicus Cke.

Fomes applanatus Fr.

Polystichus hirsutus Fr.

Polystichus tabacinus Cke.

Daedalia subsulcata B. & Br.

Favolus rhipidium Sacc.

Schizophyllum commune Fr.

Forest; on decaying logs.

Clathrus cibarius Fisch.

On ground, in forest.

Art. VI.—*A Revision of the Classification of New Zealand* Caradrinina.

By E. Meyrick, B.A., F.R.S.

[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

I have here revised the genera of *Caradrinina* occurring in New Zealand, taking into consideration the large amount of work done in the group of late years, especially by Professor J. B. Smith and Sir George Hampson. Both these authors have done admirable work in the careful investigation of structural characters, but in my judgment both have made too many genera, and have thus been led in some cases to rely upon points of distinction that are indefinite, slight, unimportant, unnatural, or even illusive and imaginary; and Sir George Hampson has unfortunately adopted a principle of generic nomenclature which I believe is not now held by any other leading lepidopterists, and is never likely to meet with general acceptance. It will be well, therefore, to begin by making some general remarks explanatory of my own principles and practice in these two subjects.

In the matter of generic nomenclature I hold as follows :—

(1.) A generic name is void if published without description. Hampson agrees, but there are writers who do not. The names of Hübner's Tentamen are therefore void.

(2.) Where an original genus included more than one species, and the author has not in any way expressed which species was typical, later writers can limit the meaning of the genus at pleasure by expressed intention (accidental limitation by casual mention has no effect), such limitations taking effect in order of priority. Hampson assumes the first species of those mentioned by the original author to be the type, which is certainly simple, but has no other justification whatever, and it would be equally simple to assume the last.

(3.) Fifty years' use in a particular sense establishes a title, and bars claim of priority.

On these principles a reasonable and legitimate use is obtained without much disturbance of recognized nomenclature.

As to the characterization of genera, no doubt the subject is a very difficult one, and there will always be room for much difference of opinion. But a genus must represent a definite section of a branch of the genealogical tree ; it must not be made up of two sections tied together, or it will be unnatural, and, whilst it is certainly not always possible to define absolutely the distinction between two genera, an author must have structural grounds for referring any species to one or other, or the genera will be impracticable. A genus must be geographically consistent : it must have originated in one place only, and have spread thence to other regions, and its geographical distribution should not be incongruous ; if it is, the supposed genus should be regarded with suspicion. Closely allied species must not be placed in genera regarded as phylogenetically remote. The value of a character for generic definition can only be determined practically ; in one set of insects a particular character may be fixed and sufficient for generic and even family limitation, and in another the very same

character may be variable even within the limits of the same species; therefore we must not assume that if a character separates natural genera in one instance it will also do the same in another. There is no scientific reason why secondary sexual characters should not be used to define genera in those cases where they are found to indicate natural genera in accordance with the above-mentioned principles; tufts of hair (probably scent-producing) in the male sex are, however, found in practice to be of specific value only—at any rate, as a general rule. Hampson oddly and inconsistently refuses to use any sexual characters for defining genera, whilst invariably employing these same characters, even the specific tufts of hairs, for forming sections of genera; whereas these should in any case be limited on exactly the same principles as genera, being of smaller value but precisely the same nature.

I will give one or two specific instances of the unsatisfactory nature of Hampson's results, to illustrate my meaning. Hampson makes a new genus *Eriopygodes* for two European species and the Hawaiian *euclidias* Meyr. This could only be explained geographically by supposing that at some former period a straggler of the genus from Europe had reached the Hawaiian Islands, which is unlikely, but, of course, possible. But *euclidias* is an insect of striking appearance, and two other Hawaiian species, *compsias* Meyr. and *niphadopa* Meyr., are structurally and superficially so close to it that it is impossible to doubt they are closely related. These are placed about seventy pages off in the genus *Hyssia*, which contains about fifteen North American, European, and New Zealand species, and a separate origin from another straggler is required for them. The difference stated is that *Hyssia* has the thorax clothed with scales mixed with hair, the abdomen with dorsal crest on first segment; *Eriopygodes*, the thorax clothed with hair only, abdomen without crests. But *euclidias* (of which I have a long series) certainly has a small abdominal crest, and the difference in clothing of thorax is imperceptible. I conclude that *euclidias* must be transferred to *Hyssia*. But the only distinction between *Hyssia* and the cosmopolitan genus *Cirphis*, with 140 species, is that *Hyssia* has the thorax clothed chiefly with hair-like scales, and *Cirphis* almost entirely with hair. This is a distinction without a difference, and, in effect, I am quite unable to distinguish the species assigned to these two genera by this or any other structural character, though they are separated by two hundred pages, and placed in widely remote branches of the phylogenetic tree. I am therefore obliged to unite them, which makes the Hawaiian species a local group representative of a cosmopolitan genus, and puts quite a different face on the matter. But on examining *Eriopyga*, with 100 species (chiefly American, some European), only stated to differ from the above by absence of abdominal crest, I find that some at any rate (*e.g.*, the European *Turca* L.) certainly possess a small crest (no doubt the character is often difficult of observation, because the base of abdomen is clothed with rough hairs, and the thoracic hairs tend to conceal it also, but when present it is formed by scales of a different character and different colour), and must be referred to *Hyssia* also. I am not well supplied with the American species, but the genus at least requires cleansing. And *Borolia*, with forty species, mostly African and Australian, is only stated to differ from *Eriopyga* exactly as *Hyssia* does from *Cirphis*, a distinction found to be inappreciable, for the supposed difference in form of wing (more oblique termen) cannot be seriously regarded as a generic character, and therefore this also needs reconsideration.

Finally, *Sideridis*, admitted to have the basal crest of abdomen, and only stated to differ from the above genera by having thorax clothed entirely with hair (for we are called upon to distinguish three genera solely by their having the thorax clothed respectively "entirely with hair," "almost entirely with hair," and "chiefly with hair-like scales"—a hair-splitting task indeed), certainly possesses hair-scales in the thorax of at least some species (*e.g.*, the European *lithargyria* Esp.), and must, in my opinion, be united with the *Hyssia-Cirphis* group as one genus, for which the name *Aletia* has some authority of use, and must be adopted.

Now we will take an instance from the Agrotid group. *Heliothis*, in the sense in which Hampson uses it, is distinguished from *Chloridea*, which includes most of the species usually regarded as typical *Heliothis*, by having the eyes small and reniform, whilst in *Chloridea* they are large and rounded. The term "reniform" (kidney-shaped) I regard as inaccurate. I have never seen an eye to which I could apply that description. Smith calls them oval, but perhaps ovate would be more correct, or suboval. But the species placed in *Heliothis* are considerably smaller insects, and the reduction in the size of the eye is hardly, if at all, more than proportionate to the reduction in the size of the insect, whilst the alteration in shape is very slight; and in *ononis* F. the eye is really small, more reduced relatively than in *Heliothis*, and similar in form (this is admitted by Smith, but not mentioned at all by Hampson), and yet this species is assigned to *Chloridea* on superficial appearance. I would unite these genera under the name of *Heliothis*; but even if they were kept separate I should still use *Heliothis* for what Hampson calls *Chloridea*, and I gather that Smith would agree with me, such being the established use. Probably, however, *Heliocheilus*, a group characterized by a special type of secondary sexual characters but included by Hampson under *Chloridea*, should be separated as a good genus. *Pyrocleptria* (Hampson) is no longer distinguishable from the combined *Heliothis-Chloridea* group, and must be merged in it. The presence or absence of a corneous ridge across the frontal prominence or a corneous plate below it seems to me of little importance in this group, leading to a multiplication of small similar genera without significance, and I should treat is as of little more than specific value. On that view Hampson's genera *Melaporphyria*, *Neocleptria*, *Rhodocleptria*, *Rhodophora*, and *Melicleptria* would also be merged in *Heliothis*, except that the *Canthylidia* group of *Melicleptria* would be tenable as a distinct genus. This combination of eight genera would, after all, only make a genus of some thirty-five species, and would be natural and coherent; whilst I would similarly write another characteristically American group of genera, varying in the same way, under the name *Schinia* Hb., distinguishable from *Heliothis* by the possession of several claws on outer side of fore tibiae instead of one. These two natural groups are unnaturally intermixed in Hampson's arrangement.

I could multiply these instances, but perhaps the above will be sufficient to show why I am unable to accept Hampson's general results without considerable sifting. I am in no sense denying the value of his work, and the following classification will exemplify that I have found points for acceptance as well as for rejection.

CARADRININA.

I adhere to my view that the name *Noctua*, carrying with it the group-names *Noctuidae* and *Noctuina*, is inapplicable in this connection, and it has now been abandoned by most authorities; but Hampson proposes to

use it in a sense in which it has never been used by any one, a result of his principle which can only induce confusion.

The *Caradrinina* are a highly developed modern group of immense extent, but, with the exception of the Melanchrid group of the *Caradrinidae*, they are represented in New Zealand only by a very few scattered stragglers, and some very extensive families and subfamilies are not represented at all. There can be little doubt that these stragglers are the outcome of accidental wind-borne immigration over a wide expanse of sea, which accounts for their scantiness. If New Zealand ever had easy communication with any land, such land did not at that time contain any of these poorly represented groups; but, as these groups are of relatively recent origin, such communication may have existed in earlier times. Now, as the Melanchrid group possesses no sort of advantage that would explain their easier introduction, and as this group is, on the whole, quite as well developed in New Zealand as in any other region, I consider it good evidence that an easy communication with some land did once exist, and that the Melanchrid group then existed in the land in question and made their way into New Zealand. It does not follow that the Melanchrid group is older than any other group of the *Caradrinina*, because any or all of the other groups may have coexisted at the same time in other regions cut off from New Zealand and the land in question by wide seas. This raises the interesting problem of determining where the land in question was, and a proper comprehension of the classification and geographical distribution of the Melanchrid group would enable us to solve it with tolerable certainty. We do not yet possess this comprehension, but offer the following considerations. The only possible lands seem to be four—viz., Australia, the Pacific islands, South America, and the Antarctic Continent. Australia may be excluded; the Melanchrid fauna is pretty well known, and makes no near approximation to that of New Zealand. The South Pacific islands are certainly incompletely known, but there is no evidence that what exists of them at the present day possesses any special Melanchrid fauna such as might be expected on this assumption. The Antarctic Continent naturally possesses no existing fauna, and, although it may have served as a route of communication, there is nothing to show that it ever had one of an aboriginal type. We are therefore reduced to look to South America, and the few species known from Chile, Patagonia, and the Falkland Isles (probably only a small fraction of those existing) are of a character which, in my opinion, agrees well with the New Zealand types, and probably indicates real affinity. I suppose, therefore, that the Melanchrid fauna entered New Zealand from South America, probably by way of the antarctic land, where it may have undergone some modification during a perhaps prolonged passage, at a date so far remote that considerable specific and some generic development has taken place since. With it doubtless came *Xanthorhoe*, *Notoreas*, *Selidosema*, *Crambus*, *Diptychophora*, *Scoparia*, and *Borkhausenia*, the largest and most characteristic genera of the New Zealand lepidopterous fauna. Probably the original source of this fauna was the temperate regions of the Northern Hemisphere, and it travelled to South America by the great mountain-chain of the Rocky Mountains and Andes. At the time when this fauna left North America probably the Indian region, which has been the principal source of lepidopterous evolution, was isolated, and extensive developments may have been going on there; but, as the *Caradrinidae* as a whole must have originated in some one region, it certainly seems that the Melanchrid group must have been, speaking generally,

the earliest branch of the family, and I propose to regard it as such on this ground, since the structural characters are such as to give no help either for or against the theory.

The generic characters given below are, for simplicity, drawn to apply to New Zealand species only.

1. ARCTIADAE.

Vein 8 of hindwings anastomosing with upper margin of cell from base to near middle.

A large cosmopolitan family, which is barely represented, whilst the allied Syntomid, Nolid, and Lithosiad groups are entirely absent.

1. Metacrias Meyr.

Metacrias Meyr., Proc. Linn. Soc. N.S.W., 1886, 749 ; type, *erichrysa* Meyr.

Tongue obsolete. Antennae in ♂ bipectinated to apex. Palpi short, hairy, concealed in long hairs of head. Thorax and femora densely hairy beneath. Anterior tibiae with apical claw, posterior tibiae without median spurs. Forewings with 7 and 8 out of 9, 10 sometimes connected with 9 above 7. Hindwings with 3, 4, 5 nearly approximated, 6 and 7 connate or short-stalked, 8 anastomosing to $\frac{1}{3}$ of cell. Wings in ♀ rudimentary or absent.

This interesting endemic genus is of doubtful affinity, but appears to be nearest to *Ocnogyna*, which is a genus of about a dozen species located round the shores of the Mediterranean ; Hampson also assigns to it one species from Peru.

1. *M. Huttoni* Butl., Cist. Ent., 2, 487 ; Meyr., Proc. Linn. Soc. N.S.W., 1886, 750 ; Huds., N.Z. Moths, 5, pl. 4, 6 ; Hamps., Cat., 3, 468.
   Lake Wakatipu.
2. *M. erichrysa* Meyr., Proc. Linn. Soc. N.S.W., 1886, 749 ; Huds., N.Z. Moths, 4, pl. 4, 5 ; Hamps., Cat., 3, 469.
   Mount Arthur ; 4,000 ft. Larva on *Senecio*.
3. *M. strategica* Huds., Entom., 1889, 53 ; *ib.*, N.Z. Moths, 4, pl. 4, 4 ; Hamps. Cat., 3, 468.
   Richardson Range ; 3,000 ft.

2. Utetheisa Hübn.

Utetheisa Hübn., Verz., 168 (1823) ; type, *ornatrix* Linn. *Deiopeia* Steph., Ill. Brit. Ent. Haust., 2, 92 (1829) ; type, *pulchella* Linn.

Head smooth. Tongue developed. Antennae in ♂ ciliated, with longer setae at joints. Palpi moderate, ascending, with loosely appressed scales. Thorax smooth beneath. Posterior tibiae with all spurs very short. Forewings with 7 and 8 out of 9, 10 connected with 9. Hindwings with 3, 4, 5 rather approximated, 6 and 7 connate or short-stalked, 8 anastomosing to middle of cell.

A small cosmopolitan genus.

4. *U. pulchella* Linn., Syst. Nat., 1, 534 (1758) ; Meyr., Trans. N.Z. Inst., 22, 217 ; Huds., N.Z. Moths, 3, pl. 4, 3.
   Wellington district. A recent immigrant, doubtfully established ; occurs throughout Europe, Asia, Africa, Australia, and South Pacific islands. Larva on *Myosotis*, grasses, &c.

2. HYPSIDAE.

Vein 8 of hindwings connected with cell by bar near base.

A rather small family, chiefly tropical. The following genus was formerly placed in the *Arctiadae*, the approximation of vein 8 being so close that it appears to be anastomosis.

3. Nyctemera Hübn.

Nyctemera Hübn., Verz., 178 (1823); type, *lacticinia* Cram. *Leptosoma* Boisd., Voy. Astr. 5, 197 (1832); type, *annulata* Boisd.

Head smooth. Tongue developed. Antennae in ♂ bipectinate to apex. Palpi moderately long, subascending, with appressed scales, terminal joint moderate, cylindrical. Forewings with 7 and 8 out of 9, 10 connected with 9 by bar. Hindwings with 6 and 7 sometimes stalked, 8 closely appressed to cell towards base, connected by bars at each end of appressed portion.

An Indo-Malayan genus of some extent, spreading into Australia and Africa; the New Zealand species is endemic, but approaches Australian forms.

5. *N. annulata* Boisd., Voy. Astr., 5, 197, pl. 5, 9; Meyr., Proc. Linn. Soc. N.S.W., 1886, 760; Huds., N.Z. Moths, 2, pl. 4, 1, 2: *doubledayi* Walk., Cat., 2, 392.

North, South, and Stewart Islands. Larva on *Senecio*.

3. CARADRINIDAE.

Vein 8 of hindwings shortly anastomosing with cell near base, thence diverging; 5 obsolete or imperfect, rising from middle of transverse vein.

An extremely large family, of which, as explained above, only one subfamily is adequately represented in New Zealand.

Subfam. 1. AGROTIDES.

Eyes glabrous; tibiae spinose.

4. Heliothis Ochs.

Heliothis Ochs., Schmett. Eur., 4, 91 (1816); type, *dipsacea* Linn. *Chloridea* Westw., Jard. Nat. Libr., 32, 198 (1841); type, *virescens* Fab.

Face with rounded prominence. Antennae in ♂ ciliated. Thorax and abdomen without crest. Interior tibiae with apical inner and outer claws.

A rather small cosmopolitan genus, of which some species range very widely; one of these has reached New Zealand. There are about a dozen other generic synonyms, which it seems needless to quote; some are explained in the preliminary remarks.

6. *H. armigera* Hübn., Samml. Eur. Schmett., 370; Meyr., Trans. N.Z. Inst., 19, 34; Huds., N.Z. Moths, 32, pl. 5, 40, 41: *conferta* Walk., Cat., 9, 690.

North and South Islands; a cosmopolitan insect. Larva polyphagous, on seeds and flowers.

5. Euxoa Hübn.

Euxoa Hübn., Verz., 209 (1823); type, *decora* Hübn.

Face with small truncate-conical prominence with raised rim. Antennae in ♂ bipectinated, towards apex simple. Thorax with rather spreading anterior and posterior crests. Abdomen without crests.

An extensive cosmopolitan genus. There are about twenty generic synonyms.

7. *E. radians* Guen., Noct., 1, 261; *munda* Walk., Cat., 10, 348; *basinotata*, *ib.*, 15, 1686; *turbulenta*, *ib.*, 32, 703; *injuncta*, *ib.*, 32, 703; *scapularis* Feld., Reis. Nov., pl. 110, 13.
   Dunedin. Common in Australia; also from Friendly Islands and Norfolk Island.

8. *E. admirationis* Guen., Ent. Mo. Mag., 5, 38; Huds., N.Z. Moths, 31, pl. 5, 37: *sericea* Butl., Cist. Ent., 2, 490; Huds., N.Z. Moths, 31, pl. 5, 38: *inconspicua* Butl., Cist. Ent., 2, 545.
   Christchurch district.

9. *E. ceropachoides* Guen., Ent. Mo. Mag., 5, 39; Huds., N.Z. Moths, 32, pl. 6, 1.
   Rakaia.

6. Agrotis Ochs.

Agrotis Ochs., Schmett. Eur., 4, 66 (1816); type, *ypsilon* Rott.
Lycophotia Hübn., Verz., 215 (1827); type, *strigula* Thunb.

Face without prominence. Antennae in ♂ bipectinated, towards apex simple. Thorax with anterior and posterior crests. Abdomen without crests. Anterior tibiae short, thickened, not longer than first joint of tarsi. A rather limited but generally distributed genus. Hampson separated *Agrotis* and *Lycophotia* by the "rather flattened" abdomen of the former, but it is quite impossible to distinguish them practically by this indefinite test.

10. *A. ypsilon* Rott., Naturf., 9, 141; Meyr., Trans. N.Z. Inst., 19, 32; Huds., N.Z. Moths, 30, pl. 5, 35, 36: *suffusa* Hübn., Samml. Eur. Schmett., 134.
    North and South Islands; a cosmopolitan insect. Larva polyphagous.

11. *A. innominata* Huds., N.Z. Moths, 31, pl. 5, 39.
    Wellington, Christchurch.

7. Graphiphora Ochs.

Graphiphora Ochs., Schmett. Eur., 4, 68 (1816); type, *obscura* Brahm.

Face without prominence. Antennae in ♂ ciliated. Thorax with anterior and posterior crests. Abdomen without crests. Anterior tibiae moderate, longer than first joint of tarsi.

A large genus, of universal distribution. Hampson includes this genus in *Agrotis*, but I think the separation is natural and practicable. This is the group to which the name of *Noctua* was formerly applied, but it has now been generally discarded. There are numerous generic synonyms.

12. *G. compta* Walk., Cat., 10, 404: *immunis*, *ib.*, 10, 430: Huds., N.Z. Moths, 7, pl. 5, 29: *quadrata* Walk., Cat., 11, 745: *innocua*, *ib.*, 15, 1710: *reciproca*, *ib.*, 32, 672: *breviuscula*, *ib.*, 33, 716: *communicata*, *ib.*, 33, 716: *acetina* Feld., Reis. Nov., pl. 109, 6.
North and South Islands. Common in Australia, and reaching New Hebrides. Larva on *Urtica*.

Subfam. 2. POLIADES.

Eyes glabrous, but overhung by long cilia from margins; tibiae not spinose.

8. Austramathes Hamps.

Austramathes Hamps., Cat., 6, 492 (1906); type, *purpurea* Butl.

Face without prominence. Terminal joint of palpi rather long. Antennae in ♂ ciliated. Thorax with divided anterior and spreading posterior crests. Abdomen without crests. An endemic genus of somewhat doubtful affinity; it is not very distinct, but the palpi are rather characteristic.

13. *A. purpurea* Butl., Cist. Ent., 2, 490; Huds., N.Z. Moths, 8, pl. 5, 32: *ceramodes* Meyr., Trans. N.Z. Inst., 19, 31.
Wellington, Dunedin.

9. Hypnotype Hamps.

Hypnotype Hamps., Cat., 6, 411 (1906); type, *placens* Walk.

Face without prominence. Antennae in ♂ ciliated. Thorax with anterior angles ridged and projecting, and with anterior and posterior crests. Abdomen without crests.

This genus is founded on a single South American species. I can only refer the following species to it with considerable doubt, as I have not a specimen for examination, and Hampson, unfortunately, had not seen a specimen either, but his conjectural reference of it to *Sympistis* is, I think, undoubtedly wrong.

14. *H. pessota* Meyr., Trans. N.Z. Inst., 19, 29; Huds., N.Z. Moths, 6, pl. 5, 26.
Wellington, Christchurch district.

10. Homohadena Grote.

Homohadena Grote, Bull. Buff. Soc. Nat. Sci., 1, 180 (1873); type *badistriga* Grote.

Face without prominence. Antennae in ♂ ciliated. Thorax without crests. Abdomen without crest.

A small American genus, in which the following species seems better placed than in *Sympistis*, where Hampson refers it, attributing to it the character of "eyes small and reniform," which I do not consider justified.

15. *H. fortis* Butl., Cist. Ent., 2, 549; *iota* Huds., Trans. N.Z. Inst., 35, 243, pl. 30, 3.
Wellington, Marlborough Province, Invercargill.

Subfam. 3. Melanchrides.

Eyes hairy ; tibiae not spinose.

11. Ichneutica Meyr.

Ichneutica Meyr., Trans. N.Z. Inst., 19, 13 (1887); type, *ceraunias* Meyr.

Face without prominence. Antennae in ♂ strongly bipectinated to apex. Thorax clothed with hair, without crests. Abdomen without crest.

An endemic genus, doubtless a local development of *Leucania*.

16. *I. dione* Huds., N.Z. Moths, 14, pl. 4, 27.
Mount Arthur ; 4,400 ft.

17. *I. ceraunias* Meyr., Trans. N.Z. Inst., 19, 13 ; Huds., N.Z. Moths, 14, pl. 4, 25, 26.
Mount Arthur ; 3,600 ft.

12. Leucania Ochs.

Leucania Ochs., Schmett. Eur., 4, 81 (1816) ; type, *pallens* Linn.

Face without prominence. Antennae in ♂ bipectinated with apex simple, or ciliated. Thorax clothed with hair, without crests. Abdomen without crest.

A considerable genus, of universal distribution, as now restricted. I include here nearly all the species of Hampson's *Borolia*.

18. *L. Purdii* Fer., Trans. N.Z. Inst., 15, 195 ; Huds., N.Z. Moths, 10, pl. 4, 11.
Wellington, Dunedin.

19. *L. acontistis* Meyr., Trans. N.Z. Inst., 19, 9 ; Huds., N.Z. Moths, 11, pl. 4, 14.
Castle Hill.

20. *L. unica* Walk., Cat., 9, 112 ; Huds., N.Z. Moths, 12, pl. 4, 17 : *juncicolor* Guen., Ent. Mo. Mag., 5, 2.
Blenheim, Rakaia, Macetown.

21. *L. toroneura* Meyr., Trans. Ent. Soc. Lond., 1901, 565 ; Hamps., Cat., 5, 591, pl. 96, 1.
Mount Cook.

22. *L. lissoxyla* Meyr., Trans. N.Z. Inst., 43, 70.
Mount Arthur ; 4,000 ft.

23. *L. phaula* Meyr., Trans. N.Z. Inst., 19, 10 ; Huds., N.Z. Moths, 11, pl. 4, 15 : *dunedinensis* Hamps., Cat., 5, 591, pl. 96, 2 : *neurae* Philp., Trans. N.Z. Inst., 37, 330, pl. 20, 5.
Christchurch, Dunedin, Invercargill. Larva on tussock-grass.

24. *L. alopa* Meyr., Trans. N.Z. Inst., 19, 10 ; Huds., N.Z. Moths, 12, pl. 4, 16.
Lakes Coleridge and Guyon.

25. *L. blenheimensis* Fer., Trans. N.Z. Inst., 15, 196 ; Huds., N.Z. Moths, 13, pl. 4, 23.
Napier, Blenheim.

26. *L. semivittata* Walk., Cat., 32, 628; Huds., N.Z. Moths, 13, pl. 4, 21, 22.
North and South Islands.

27. *L. sulcana* Fer., Trans. N.Z. Inst., 12, 267, pl. 9, 3; Huds., N.Z. Moths, 13, pl. 4, 19, 20.
Akaroa, Dunedin.

28. *L. stulta* Philp., Trans. N.Z. Inst., 37, 330, pl. 20, 1.
Invercargill district.

13. Aletia Hübn.

Aletia Hübn., Verz., 239 (1823); type, *conigera* Fab. *Sideridis* Hübn., Verz., 232 (1823); type, *evidens* Hübn. *Hyssia* Guen., Noct., 1, 345 (1852); type, *cavernosa* Ev. *Chabuata* Walk., Cat., 14, 1034 (1857); type, *ampla* Walk. *Cirphis* Walk., Cat., 32, 622 (1865); type, *costalis* Walk. *Alysia* Guen., Ent. Mo. Mag., 5, 3 (1868); type, *nullifera* Guen.

Face without prominence. Antennae in ♂ ciliated, or bipectinated with apex simple. Thorax clothed with hair or hair-scales, with anterior and posterior spreading crests. Abdomen with small crest on basal segment.

A very large and cosmopolitan genus. Hampson includes *micrastra* in *Physetica*, on the ground of the increased size of the spines of the anterior tibiae; the difference is, however, merely comparative, and, as there seems to be no near relationship in other particulars, insistence on this particular character produces an artificial and unnatural collocation.

29. *A. micrastra* Meyr., Trans. Ent. Soc. Lond., 1897, 383; Huds., N.Z. Moths, 12, pl. 4, 10.
Wellington.

30. *A. Loreyi* Dup., Lép. Fr., 7, 81, pl. 105, 7; Hamps., Cat., 5, 492.
Kermadec Islands. Widely distributed in Europe, Asia, Africa, and Australia.

31. *A. unipuncta* Haw., Lép. Brit., 174; Huds., N.Z. Moths, 13, pl. 4, 24: *extranea* Guen., Noct., 1, 77.
North and South Islands. A cosmopolitan species. Larva on grasses.

32. *A. nullifera* Walk., Cat., 11, 742; Huds., N.Z. Moths, 9, pl. 4, 9: *specifica* Guen., Ent. Mo. Mag., 5, 3.
Taupo, Wellington, Mount Arthur (4,000 ft.), Christchurch district.

33. *A. moderata* Walk., Cat., 32, 705; Meyr., Trans. N.Z. Inst., 20, 45: *sistens* Guen., Ent. Mo. Mag., 5, 39: *mitis* Butl., Proc. Zool. Soc. Lond., 1877, 383, pl. 42, 5: *griseipennis* Huds., N.Z., Moths, 9, pl. 4, 8.
North and South Islands.

34. *A. griseipennis* Feld., Reis. Nov., pl. 109, 22; *virescens* Butl., Cist. Ent. 2, 489.
Wellington, South Island.

35. *A. temenaula* Meyr., Trans. N.Z. Inst., 39, 107.
Rakaia, Dunedin.

36. *A. pachyscia* Meyr., Trans. N.Z. Inst., 39, 107.
Mount Arthur (4,700 ft.), Lake Wakatipu.

37. *A. falsidica* Meyr., Trans. N.Z. Inst., 43, 70.
Mount Arthur, Lake Wakatipu.

38. *A. sminthistis* Hamps., Cat., 5, 280, pl. 86, 17.
Locality unrecorded.

39. *A. inconstans* Butl., Cist. Ent., 2, 545.
Wellington, Marlborough.

40. *A. cucullina* Guen., Ent. Mo. Mag., 5, 40; Huds., N.Z. Moths, 27, pl. 5, 23.
Christchurch district, Mount Arthur (3,600 ft.).

14. Physetica Meyr.

Physetica Meyr., Trans. N.Z. Inst., 19, 5 (1887); type, *caerulea* Guen.

Face without prominence. Antennae in ♂ ciliated. Palpi in ♂ with terminal joint greatly dilated, with orifice on outer side (instead of apex). Thorax clothed with hair, without crests. Abdomen with small crest on basal segment.

Probably an endemic development of *Aletia*.

41. *P. caerulea* Guen., Ent. Mo. Mag., 5, 38; Huds., N.Z. Moths, 8, pl. 4, 7.
Wellington, Blenheim, Rakaia.

15. Dipaustica n.g.

Face with strong horny bifurcate process. Antennae in ♂ ciliated. Thorax clothed with hair and hair-scales, with strong triangular divided anterior crest. Abdomen with crest on basal segment. Anterior tarsi with spines unusually small and slight.

A distinct endemic genus; a development of *Aletia*.

42. *D. epiastra* Meyr., Trans. N.Z. Inst., 43, 58.
Makara. Larva in stems of *Arundo conspicua*.

16. Persectania Hamps.

Persectania Hamps., Cat., 5, 386; type, *composita* Guen. *Graphania* Hamps., Cat., 5, 469; type, *disjungens* Walk. *Tmetolophota* Hamps., Cat., 5, 470; type, *propria* Walk.

Face with slight rounded or subtruncate prominence with ridge below it. Antennae in ♂ ciliated, or bipectinated with apex simple. Thorax clothed with hair and hair-scales, with anterior and posterior crests. Abdomen with crest on basal segment.

Apparently a development of *Melanchra*. Hampson includes in *Graphania* an African species, and in *Tmetolophota* a South American one, which I have not seen.

43. *P. disjungens* Walk., Cat., 15, 1681; Huds., N.Z. Moths, 15, pl. 5, 43: *nervata* Guen., Ent. Mo. Mag., 5, 40.
Ashburton, Rakaia.

44. *P. steropastis* Meyr., Trans. N.Z. Inst., 19, 22; Huds., N.Z. Moths, 23, pl. 5, 10, 11.
Napier, South Island.

45. *P. composita* Guen., Noct., 2, 114 ; Huds., N.Z. Moths, 22, pl. 5, 8, 9 : *ewingii* Westw., Proc. Ent. Soc., 2, 55, pl. 20, 1 : *aversa* Walk., Cat., 9, 113 : *maori* Feld., Reis. Nov., pl. 109, 24 : *peracuta* Morr., Bull. Buff. Soc. Nat. Sci., 2, 114 : *dentigera* Butl., Cist. Ent., 2, 542.
North and South Islands ; common also in Australia. Larva on grasses. I see no reason to revive Westwood's forgotten name in face of the established use, still less under Hampson's unrecognizable amended form *evingi*.

46. *P. arotis* Meyr., Trans. N.Z. Inst., 19, 11 ; Huds., N.Z. Moths, 12, pl. 4, 18 : *aulacias* Meyr., Trans. N.Z. Inst., 19, 11.
Wellington, South Island.

47. *P. atristriga* Walk., Cat., 33, 756 ; Huds., N.Z. Moths, 10, pl. 4, 12 : *antipoda* Feld., Reis. Nov., pl. 109, 23.
North and South Islands.

48. *P. propria* Walk., Cat., 9, 111 ; Huds. N.Z. Moths, 11, pl. 4, 13.
Blenheim, Mount Arthur (3,800 ft.), Mount Hutt.

17. Erana Walk.

Erana Walk., Cat. 11, 605 (1857) ; type, *graminosa* Walk.

Face without prominence. Antennae in ♂ with scattered cilia. Thorax clothed with scales, with anterior and posterior spreading crests. Abdomen with strong dorsal crests towards base. Forewings with 10 not connected with 9 to form areole, in ♂ beneath with very long tuft of scent-producing hairs from basal area. Hindwings in ♂ with costal area broadly expanded.

An endemic development of *Melanchra*.

49. *E. graminosa* Walk., Cat., 11, 605 ; Huds., N.Z. Moths, 28, pl. 5, 24, 25 : *vigens* Walk., 33, 743.
North and South Islands. Larva on *Melicytus ramiflorus*.

18. Melanchra Hübn.

Melanchra Hübn., Verz., 207 (1823) ; type, *persicariae* Linn. *Meterana* Butl., Proc. Zool. Soc. Lond., 1877, 385 ; type, *pictula* White.

Face without prominence. Antennae in ♂ ciliated, or bipectinated with apex simple. Thorax clothed with hair and scales, with anterior and posterior crests. Abdomen with dorsal crests towards base.

A very large genus, of universal distribution, but chiefly in temperate regions. Hampson calls this genus *Polia* (whereas this name has been universally employed in a quite different sense, and is barred), but separates all the New Zealand species except *pictula* and *rhodopleura*, together with six from North America, as a widely remote genus *Morrisonia*, on the alleged character that these latter have "the tegulae dorsally produced into a ridge." I am quite unable to separate the two groups on this or any other character, and think the division unnatural, the species of both being very similar in all respects. The use of the name *Mamestra* for this genus is not practicable ; it is founded on Guenée's use, but under a misapprehension of it, as Guenée himself specified the type as *furva* Hübn., which does not belong to this subfamily at all. There are a number of generic synonyms, which I do not quote.

50. *M. pictula* White, Tayl. New Zeal., pl. 1, 3 ; Huds., N.Z. Moths, 19, pl. 4, 37.
Lake Coleridge.

51. *M. rhodopleura* Meyr., Trans. N.Z. Inst., 19, 19 ; Huds., N.Z. Moths, 19, pl. 4, 38.
Auckland, Napier, Wellington. Hampson oddly unites this and the preceding as sexes, which is certainly incorrect, as I have males of both. They are also not only distinct and apparently constant in colouring, but differ somewhat in the form of the spots, occur in different Islands, and my type of *pictula* has the tegulae distinctly ridged, and would therefore be placed by him in a different genus from *rhodopleura*, in which there seems to be no ridge ; however, on this last point I lay no stress myself.

52. *M. exquisita* Philp., Trans. N.Z. Inst., 35, 246, pl. 32, 2.
Invercargill.

53. *M. plena* Walk., Cat., 33, 744 ; Huds., N.Z. Moths, 17, pl. 4, 32 : *sphagnea* Feld., Reis. Nov., pl. 109, 17 : *viridis* Butl., Cist. Ent., 2, 547.
Wellington, South Island. Larva on grasses and low plants.

53A. *M. pauca*, Philp., Trans. N.Z. Inst., 42, 544.
Wairarapa, Invercargill.

54. *M. octans* Huds., N.Z. Moths, 25, pl. 5, 1.
Invercargill.

55. *M. grandiosa* Philp., Trans. N.Z. Inst., 35, 246, pl. 32, 1.
Invercargill.

56. *M. decorata* Philp., Trans. N.Z. Inst., 37, 329, pl. 20, 2.
Invercargill.

57. *M. maya* Huds., N.Z. Moths, 17, pl. 4, 31.
Mount Arthur (3,500 ft.), Macetown.

58. *M. xanthogramma* Meyr., Trans. N.Z. Inst., 44, 117.
Wellington.

59. *M. insignis* Walk., Cat., 33, 724 ; Huds., N.Z. Moths, 16, pl. 4, 29, 30 ; Hamps., Cat. 5, 368, pl. 88, 20 : *turbida* Walk., Cat., 33, 754 : *skelloni* Butl., Cist. Ent., 2, 547 : *polychroa* Meyr., Trans. N.Z. Inst., 19, 16.
North and South Islands. Larva polyphagous on low plants.

60. *M. mutans* Walk., Cat., 11, 602 ; Huds., N.Z. Moths, 18, pl. 4, 34–36 ; Hamps., Cat., 5, 369, pl. 38, 21 : *lignifusca* Walk., Cat., 11, 603 : *spurcata*, *ib.*, 11, 631 : *vexata*, *ib.*, 33, 755 : *angusta* Feld., Reis. Nov., pl. 109, 18 : *acceptrix*, *ib.*, pl. 109, 19 : *debilis* Butl., Proc. Zool. Soc. Lond., 1877, 385, pl. 42, 6.
North and South Islands. Larva polyphagous on low plants.

61. *M. bromias* Meyr., Trans. Ent. Soc. Lond., 1902, 273 ; Hamps., Cat., 5, 370, pl. 88, 22.
Chatham Islands.

62. *M. ustistriga* Walk., Cat., 11, 630 ; Huds., N.Z. Moths, 26, pl. 5, 20 : Hamps., Cat., 5, 377, pl. 88, 29 : *lignisecta* Walk., Cat., 11, 631.
North and South Islands. Larva on *Lonicera*.

63. *M. paracausta* Meyr., Trans. N.Z. Inst., 19, 15 ; Huds., N.Z. Moths, 15, pl. 4, 28.
Mount Arthur, Castle Hill, Invercargill.

64. *M. coeleno* Huds., N.Z. Moths, 26, pl. 4, 39.
Wellington.

65. *M. diatmeta* Huds., N.Z. Moths, 21, pl. 5, 5.
Wellington.

66. *M. infensa* Walk., Cat., 11, 748; Huds., N.Z. Moths, 23, pl. 5, 12; Hamps., Cat., 5, 376, pl. 88, 27: *arachnias* Meyr., Trans. N.Z. Inst., 19, 23.
Napier, Blenheim.

67. *M. omoplaca* Meyr., Trans. N.Z. Inst., 19, 24; Huds., N.Z. Moths, 23, pl. 5, 13; Hamps., Cat., 5, 382, pl. 89, 2: *umbra* Huds., Trans. N.Z. Inst., 35, 243, pl. 30, 7–9.
Wellington, Lake Coleridge, Invercargill.

68. *M. alcyone* Huds., N.Z. Moths, 24, pl. 5, 14.
Wellington

69. *M. rubescens* Butl., Cist. Ent., 2, 489; Huds., N.Z. Moths, 25, pl. 5, 18; Hamps., Cat., 5, 376, pl. 88, 28.
Mount Arthur, Castle Hill, Dunedin, Lake Wakatipu.

70. *M. lignana* Walk., Cat., 11, 758; Huds., N.Z. Moths, 26, pl. 5, 19; Hamps., Cat., 5, 383, pl. 89, 3.
Wellington, Blenheim, Mount Hutt.

71. *M. stipata* Walk., Cat., 33, 753; Huds., N.Z. Moths, 25, pl. 5, 17.
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72. *M. merope* Huds., N.Z. Moths, 19, pl. 5, 2.
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73. *M. omicron* Huds., N.Z. Moths, 22, pl. 5, 42.
Wellington.

74. *M. dotata* Walk., Cat., 11, 522; Huds., N.Z. Moths, 24, pl. 5, 16; Hamps., Cat., 380, pl. 88, 31.
Nelson.

75. *M. asterope* Huds., N.Z. Moths, 24, pl. 5, 15.
Mount Arthur (3,600 ft.), Lake Wakatipu.

76. *M. tartarea* Butl., Proc. Zool. Soc. Lond., 1877, 384, pl. 42, 2; Huds., N.Z. Moths, 21, pl. 5, 6; Hamps., Cat., 5, 381, pl. 89, 1.
Murimutu Plains, Christchurch, Invercargill.

77. *M. agorastis* Meyr., Trans. N.Z. Inst., 19, 18; Huds., N.Z. Moths, 18, pl. 5, 30; Hamps., Cat., 5, 371, pl. 88, 23.
Wellington, Akaroa, Lake Guyon.

78. *M. vitiosa* Butl., Proc. Zool. Soc. Lond., 1877, 384, pl. 42, 3: *proteastis* Meyr., Trans. N.Z. Inst., 20, 45; Huds., N.Z. Moths, 20, pl. 4, 40.
Christchurch. Hampson, by confusion, attributes the larva of the following species to this one, and misquotes the names of Hudson's references.

79. *M. ochthistis* Meyr., Trans. N.Z. Inst., 19, 20; Hamps., Cat., 5, 380, pl. 88, 32: *vitiosa* Huds., N.Z. Moths, 20, pl. 4, 42.
Wellington, Christchurch, Dunedin. Larva on *Melicope simplex*.

80. *M. morosa* Butl., Cist. Ent., 2, 543; Hamps., Cat., 5, 384, pl. 89, 4: *pelistis* Meyr., Trans. N.Z. Inst., 19, 20; Huds., N.Z. Moths, 19, pl. 5, 3, 4.
Wellington, Paekakariki, Akaroa, Lake Coleridge.

81. *M. levis* Philp., Trans. N.Z. Inst., 37, 330, pl. 20, 4.
Invercargill.

82. *M. lithias* Meyr., Trans. N.Z. Inst., 19, 17; Huds., N.Z. Moths, 17, pl. 4, 33.
Castle Hill.

83. *M. homoscia* Meyr., Trans. N.Z. Inst., 19, 21; Huds., N.Z. Moths, 21, pl. 5, 7; Hamps., Cat., 5, 378, pl. 88, 30.
Wellington, Blenheim. Larva on *Pomaderris ericifolia.*

84. *M. temperata* Walk., Cat., 15, 1648; Hamps., Cat., 5, 385, pl. 89, 6: *inceptura* Walk., Cat., 15, 1736: *deceptura, ib.*, 1737.
Locality unknown.

85. *M. prionistis* Meyr., Trans. N.Z. Inst., 19, 27; Huds., N.Z. Moths, 27, pl. 5, 21; Hamps., Cat., 5, 384, pl. 89, 5.
Wellington, Rakaia.

86. *M. phricias* Meyr., Trans. N.Z. Inst., 20, 46; Huds., N.Z. Moths, 27, pl. 5, 22; Hamps., Cat., 5, 385, pl. 89, 7.
Manawatu district, Blenheim, Christchurch, Lake Coleridge.

19. Dasygaster Guen.

Dasygaster Guen., Noct., 1, 201 (1852); type, *hollandiae* Guen.

Face with slight rounded prominence with ridge below it. Antennae in ♂ ciliated. Thorax clothed with hair and hair-scales, with anterior and posterior crests. Abdomen with dorsal crests towards base, and dense lateral tufted fringes, especially in ♂.

A small characteristically Australian genus; the following species is perhaps a recent immigrant.

87. *D. hollandiae* Guen., Noct., 1, 201; Hamps., Cat., 5, 476: *leucanioides* Guen., Noct., 1, 202: *facilis* Walk., Cat., 11, 745.
Waipori. Common in south-east Australia and Tasmania.

Subfam. 4. Caradrinides.

Eyes glabrous, without marginal cilia; tibiae not spinose.

20. Bityla Walk.

Bityla Walk., Cat., 33, 869 (1865); type, *defigurata* Walk.

Face without prominence. Antennae in ♂ ciliated. Thorax clothed with hair, without crests. Abdomen without crests.

Apparently endemic.

88. *B. defigurata* Walk., Cat., 33, 756; Huds., N.Z. Moths, 29, pl. 5, 33: *thoracica* Walk., Cat., 33, 869.
North and South Islands.

89. *B. sericea* Butl., Proc. Zool. Soc. Lond., 1877, 387, pl. 42, 12; Huds., N.Z. Moths, 29, pl. 5, 34.
Wellington, Christchurch, Lake Guyon.

90. *B. pallida* Huds., Trans. N.Z. Inst., 37, 355; Hamps., Cat., 7, 42, pl. 109, 6.
Napier.

21. Ariathisa Walk.

Ariathisa Walk., Cat., 33, 747 (1865) : type, *excisa* Herr-Schäff.
Nitocris Guen., Ent. Mo. Mag., 5, 4 (1868) : type, *comma* Walk.

Face without prominence. Antennae in ♂ ciliated. Thorax clothed chiefly with scales, with small posterior double crest. Abdomen without crests.

A rather extensive characteristically Australian genus. The single New Zealand species is apparently endemic, but extremely close to Australian forms.

91. *A. comma* Walk., Cat., 9, 239 : Huds., N.Z. Moths, 7, pl. 5, 27, 28 ; *implexa* Walk., Cat., 10, 405 : *plusiata*, *ib.*, 33, 742 : *bicomma* Guen., Ent. Mo. Mag., 5, 4.
North and South Islands.

22. Spodoptera Guen.

Spodoptera Guen., Noct., 1, 153 (1852) ; type, *mauritia* Boisd.

Face without prominence. Antennae in ♂ ciliated. Thorax clothed chiefly with scales, with posterior spreading crest. Abdomen with dorsal crest at base.

A small widely distributed genus, of which two species have a very extensive range.

92. *S. mauritia* Boisd., Faun. Ent. Madag. Lép., 92, pl. 13, 9 ; Hamps., Cat., 8, 256 : *margarita* Hawth., Trans. N.Z. Inst., 29, 283 ; Huds., N.Z. Moths, 6, pl. 5, 31.
Wellington. Common throughout south Asia, Africa, Australia, and Pacific islands. There are sixteen specific synonyms, which I do not quote. Larva on rice, and perhaps other cereals.

23. Cosmodes Guen.

Cosmodes Guen., Noct., 2, 289 (1852) ; type, *elegans* Don.

Face without prominence. Antennae in ♂ ciliated. Thorax clothed chiefly with scales, with anterior and posterior crests. Abdomen with dorsal crests towards base, and large crest on third segment. Forewings with scale-tooth at tornus, termen angulated on vein 3.

The single species occurs apparently naturally in both Australia and New Zealand, but probably the former country is its home. It approaches the Asiatic *Canna*.

93. *C. elegans* Don., Ins. New Holl., pl. 36, 5 ; Huds., N.Z. Moths, 33, pl. 6, 2.
North Island, Christchurch. Common in eastern Australia.

4. PLUSIADAE.

Vein 8 of hindwings shortly anastomosing with cell near base, thence diverging, 5 well developed.

Also an extremely large family, but more especially characteristic of tropical regions.

Subfam. 1. HYPENIDES.

Hindwings with 5 nearly parallel to 4.

24. Hypenodes Guen.

Hypenodes Guen., Delt., 41 (1854); type, *albistrigalis* Haw.

Head with frontal tuft. Antennae in ♂ ciliated. Palpi very long, porrected, second joint thickened with rough projecting scales, terminal rather short or moderately long, cylindrical. Thorax with appressed scales. Abdomen with small crest on basal segment. Tibiae smooth-scaled. Forewings with 7 separate, 9 and 10 out of 8.

94. *H. costistrigalis* Steph., Ill. Brit. Ent., 4, 20; *exsularis* Meyr., Trans. N.Z. Inst., 20, 46.
Taranaki, Kermadec Islands. Widely distributed in Europe, Asia, and Australia.

95. *H. anticlina* Meyr., Trans. Ent. Soc. Lond., 1901, 566; *octias* Huds., N.Z. Moths, 37, pl. 6, 7.
Wellington.

Subfam. 2. Catocalides.

Hindwings with 3, 4, 5 approximated at base; middle and sometimes posterior tibiae spinose.

25. Ophiusa Ochs.

Ophiusa Ochs., Schmett. Eur., 4, 93 (1816); type, *algira* Linn. *Achaea* Hübn., Verz., 269 (1823); type, *melicerte* Drury. *Grammodes* Guen., Noct., 3, 275 (1852); type, *geometrica* Fab.

Antennae in ♂ ciliated. Palpi moderately long, ascending, second joint thickened with dense appressed scales, terminal joint moderate, somewhat pointed. Thorax clothed with scales and hair, without crest. Abdomen without crest.

An extensive genus, of general distribution, but principally tropical.

96. *O. melicerte* Drury, Ill. Exot. Ins., 1, 46, pl. 23, 1; *traversii* Fer., Trans. N.Z. Inst., 9, 457, pl. 17.
Wellington; a casual immigrant. Widely distributed in Asia, Africa, and Australia.

97. *O. pulcherrima* Luc., Proc. Linn. Soc. N.S.W., 1892, 258; Huds., Trans. N.Z. Inst., 37, 355, pl. 22, 4.
Wellington, once; probably an accidental introduction. Occurs in eastern Australia.

Subfam. 3. Plusiades.

Hindwings with 3, 4, 5 approximated at base; tibiae not spinose.

26. Plusia Ochs.

Plusia Ochs., Schmett. Eur., 4, 89 (1816); type, *gamma* Linn.

Antennae in ♂ ciliated. Palpi rather long, curved, ascending, second joint rough-scaled, terminal moderate or short, more or less rough-scaled in front, somewhat pointed. Thorax with large central or posterior crest. Abdomen with one or more crests. Tibiae rough-scaled.

An extensive nearly cosmopolitan genus; the two New Zealand species are immigrants.

98. *P. chalcites* Esp., Schmett., 447, pl. 141, 3; Huds., N.Z. Moths, 35, pl. 6, 3: *eriosoma* Doubl., Dieff. N.Z., 2, 285: *verticillata* Guen., Noct., 2, 344: *rogationis*, *ib.*, 344.
North Island, Blenheim, Nelson. A cosmopolitan insect. Larva on various plants.

99. *P. oxygramma* Hübn., Zutr., 37, f. 769, 770 ; *transfixa* Walk., Cat., 12, 884 ; *subchalybaea*, *ib.*, 33, 833.
Thames River. Widely distributed in Asia, Australia, and Pacific islands.

27. Ophideres Boisd.

Ophideres Boisd., Faun. Ent. Madag. Lép., 99 (1833) ; type, *fullonica* Linn.

Antennae in ♂ ciliated. Palpi long, ascending, second joint thickened with dense appressed scales, terminal joint moderately long, slender, somewhat thickened towards apex, obtuse. Thorax clothed with hair-scales rather expanded posteriorly. Abdomen without crests.

A rather small tropical genus, of which some species have a wide range.

100. *O. fullonica* Linn., Syst. Nat., 1, 812 ; Meyr., Trans. N.Z. Inst., 19, 37.
Christchurch, one doubtful specimen. Widely distributed in Asia, Africa, Australia, and Pacific islands.

28. Dasypodia Guen.

Dasypodia, Guen. Noct., 3, 174 (1852) ; type, *selenophora* Guen.

Antennae in ♂ ciliated. Palpi long, ascending, second joint thickened with dense scales, terminal joint moderately long, slender, somewhat thickened towards apex, obtuse. Thorax clothed with long hairs, without crest. Abdomen without crests. Posterior tibiae densely hairy.

An Australian genus ; probably of only one species.

101. *D. selenophora* Guen., Noct., 3, 175 ; Huds., N.Z. Moths, 35, pl. 6, 4.
North Island, Nelson, Christchurch. Common in south-east Australia. Larva on *Acacia* (?).

29. Rhapsa Walk.

Rhapsa Walk., Cat., 1149 (1865) ; type, *scotosialis* Walk.

Antennae in ♂ bipectinated, towards apex simple. Palpi very long, obliquely ascending, clothed with rough scales throughout, second joint above in ♂ with tuft of long projecting scales above towards apex, terminal joint moderate. Thorax clothed with scales, without crest. Abdomen without crest. Posterior tibiae with appressed scales. Forewings in ♂ beneath with large broad costal fold on anterior half.

A closely allied species occurs in south-east Australia, so similar that it might be thought identical, but with the antennae of ♂ furnished with long bristles instead of pectinations, vein 8 of hindwings anastomosing with cell to beyond middle ; the characteristic palpi and costal fold of the forewings are similar in both species.

102. *R. scotosialis* Walk., Cat., 34, 1150 ; Huds., N.Z. Moths, 36, pl. 6, 5, 6 : *lilacina* Butl., Proc. Zool. Soc. Lond., 1877, 388, pl. 42, 11.
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Art. VII.—*On the Nomenclature of the* Lepidoptera *of New Zealand.*

By G. B. Longstaff, M.A., M.D., F.E.S.

Communicated by George Howes, F.E.S.

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During the early part of 1910 it was my good fortune to spend eight weeks in New Zealand, during which I visited many places in both Islands. Naturally enough, my attention was somewhat distracted from entomology by the other attractions of the country, but in spite of these, and in spite of the shortness of the time at my disposal, I was, largely owing to the kindness of Mr. Augustus Hamilton, Mr. G. W. Howes, and Mr. G. V. Hudson, able to obtain some slight knowledge of its insect fauna.

Since returning to England many hours have been spent in the British Museum naming my captures. Moreover, I have had the opportunity of examining large consignments of New Zealand *Lepidoptera* recently received from Messrs. Hamilton and Howes. In addition, I have had the invaluable assistance of Sir George F. Hampson, Bart., and Mr. L. B. Prout, in the settlement of knotty points.

Mr. Howes suggested that I might give some of the fruits of my labours to my brother entomologists in New Zealand. Obviously, it would not be possible to place at their disposal every determination of a specimen, but perhaps I may save them some of the trouble that I had to go through myself in seeking out the comparatively small number of New Zealand moths in the serried ranks of cabinets at South Kensington.

All concerned in New Zealand entomology owe a great debt of gratitude to Mr. Hudson for his "New Zealand Moths and Butterflies," which was published in 1898. The writer of a pioneer work of that description always labours under great difficulties—difficulties which must have been in his case greatly increased by his distance from the vast collections and rich libraries of Europe.

This paper appears to be a criticism of Mr. Hudson's book, and so, indeed, it is; but it is a friendly criticism. His book has been most useful to me, alike in New Zealand and in England; and, in spite of imperfections, many of them probably unavoidable, no criticism can destroy the value of the life-histories and notes of habits and like matters, which find no place in such works as Sir George Hampson's great catalogue. All, I think, must join in hoping that some day Mr. Hudson may see his way to a second edition.

Here I would put in a word of encouragement to those who, like myself, are not systematists, and are, naturally enough, much put out by the changes of nomenclature that are nowadays so frequent. The value of a generic name is comparatively small, since genera correspond to the views of naturalists rather than to the facts of nature, and with increasing knowledge the views of naturalists change rapidly. Some divergences of opinion are due to the recognition, or otherwise, of the genera founded by older authors, which may, or may not, comply with our rules of nomenclature. Sometimes it is discovered that the author's type of the genus was a species now recognized as very different in structure from the others included with it. Sometimes a familiar old name is dropped because the type species is clearly congeneric with some earlier-described species. Many changes which seem from a New Zealand or an English point of view to be meaningless are clearly

comprehensible when a large fauna is reviewed. In short, generic names have changed, and, troublesome though it be, probably will change again.

With species, however, the case is quite different. They correspond, or should correspond, with natural facts. There will probably always be both the "splitter" and the "lumper." Nevertheless, while it is comparatively unimportant what generic name you use, it is most important, so far as possible, that all should agree as to the specific name. It is, for example, most important that you should all mean the same thing by *vitiosa* Butl., but it matters comparatively little whether you include it in *Melanchra* or *Morrisonia*.

It was almost inevitable that Mr. Hudson should have adopted Mr. Meyrick's system of classification and somewhat revolutionary nomenclature. Sir George Hampson's system differs from Mr. Meyrick's, though the difference is not perhaps so great as appears at first sight. It is well that I should state quite plainly that I am in nowise competent to judge between the two systems, and make no claim to do so. My design in this paper is a much more humble one, being merely to help New Zealand entomologists to find out by what names their moths and butterflies are known in the latest English systematic work.

A few remarks as to the formidable "Catalogue of the *Lepidoptera-Phalaenae* in the British Museum" may possibly be of interest to the members of the New Zealand Institute. The first volume was issued in 1898, the ninth, completing the *Noctuidae Trifinae*, in 1910. In these ponderous tomes, each accompanied by a fasciculus of coloured plates, illustrating species not previously figured satisfactorily, Sir George Hampson has dealt with close upon ten thousand species of moths. Vol. 3 deals with *four* New Zealand insects, vol. 4 with *eight*, vol. 6 with *four*, vol. 7 with *three*, vol. 8 with *two*. Three of the volumes (1, 2, and 9) contain no New Zealand species; but it is fortunate that no less than forty-six species, all in the subfamily *Hadenidae*, are described in vol. 5.*

Since Sir George's monumental work is likely to be the standard authority for many years to come—at any rate, for English-speaking entomologists—I have adopted his arrangement of the species in preference to that of Mr. Hudson, or that of the "Hand-list of New Zealand *Lepidoptera*."

On the left-hand side will be seen the name of the species as it stands in Mr. Hudson's book, or in the original paper in which it was described. The page, plate, and figure follow. The mark ¶ signifies that there is no illustration of the species.

On the right-hand side are given:—

(1.) The number borne by the species in the catalogue. An asterisk (*) indicates that at the time of publication there was no specimen in the British Museum. In the case of the species recognized by the author since the publication of the volume the interpolated number is given in parentheses ( ).

(2.) The name in the catalogue or in the British Museum collection.

(3.) The number, in parentheses ( ), of specimens in the collection in November, 1910. This in most cases is only given when the number is under six. When the mark ♀ is added, the ♂ is unknown to Sir George, and there is therefore some doubt as to the section of the genus in which the species should be placed.

* Vol. 5 is issued at 15s.; the accompanying plates also cost 15s.: either may be had separately.

(4.) The reference to volume, page, plate, and figure in the catalogue. "Fig." means that there is a woodcut in the text; the mark ¶ that there is no illustration of the species. When the insect has been recognized since publication, any obsolete reference to it is placed in square brackets [ ].

Ann. Mag. Nat. Hist. = "Annals and Magazine of Natural History."
Hmpsn. = "Catalogue of the *Lepidoptera-Phalaenae* in the British Museum."
Huds. = "New Zealand Moths and Butterflies," 1898.
Subantarc. Is. N.Z. = "Subantarctic Islands of New Zealand."
Trans. N.Z. Inst. = "Transactions of the New Zealand Institute."
Trans. Ent. Soc. Lond. = "Transactions of the Entomological Society of London."
Wellington list = "Hand-list of New Zealand *Lepidoptera*, Dominion Museum, Wellington, 1909."

Metacrias huttoni Butl., Huds. p. 5, iv, 6	2063. *Metacrias huttoni* Butl. (5), vol. 3, p. 468; fig.
Metacrias strategica Huds., Huds. p. 4,* iv, 4	2064. *Metacrias strategica* Huds. (3), vol. 3, p. 468. ¶.
Metacrias erichrysa Meyr., Huds. p. 4,* iv, 5	2065. *Metacrias erichrysa* Meyr. (1), vol. 3, p. 469. ¶.
Utetheisa pulchella Linn., Huds. p. 3, iv, 3	2088. *Utetheisa pulchella* Linn., vol. 3, p. 483; fig.
Nyctemera annulata Boisd., Huds. p. 2, iv, 1, 2	— *Deilemera annulata* Boisd.†
Heliothis armigera Hübn., Huds. p. 32, v, 40, 41	56. [*Chloridea armigera*] Hübn., now *C. obsoleta* Fab., vol. 4, p. 45; fig.
Euxoa radians Guen. ¶	285. *Euxoa radians* Guen. (1, from N.Z.), vol. 4, p. 164, lx, 7.
Agrotis admirationis Guen., Huds. p. 31, v, 37 *Agrotis sericea* Butl., Huds. p. 31, v, 38..	300. *Euxoa admirationis* Guen., vol. 4, p. 173; syn. *sericea* Butl. ¶.
Agrotis ceropachoides Guen., Huds. p. 32, vi, 1	* 301. *Euxoa ceropachoides* Guen. (0), vol. 4, p. 174, lxi, 7.
Agrotis ypsilon Rott., Huds. p. 30, v, 35, 36	646. *Agrotis ypsilon* Rott., vol. 4, p. 368; fig.
Orthosia immunis Walk., Huds. p. 7, v, 29	702. *Agrotis compta* Walk., vol. 4, p. 409, lxx, 18.
Agrotis innominata Huds., Huds. p. 31, v, 39	895. *Lycophotia innominata* Huds. (1), vol. 4, p. 515; fig.
Ectopatria aspera Walk., Wellington list	1123. *Ectopatria aspera* Walk. (3 N.Z.), vol. 4, p. 654, lxxvii, 27.
Erana graminosa Walk., Huds. p. 29, v, 24, 25	1128. *Erana graminosa* Walk., vol. 5, p. 8; fig.
Melanchra rhodopleura Meyr., Huds. p. 19, iv, 38	1374. [*Polia pictula* White] (3), vol. 5, p. 174. ¶. *Miselia pictula* White.‡
Melanchra pictula Butl. et Huds., *nec* White, Huds. p. 19, iv, 37	(1374A.) *Miselia meyricci* Hmpsn. *ined.*‡ (2). ¶.
Leucania griseipennis Feld., Huds. p. 9; but iv, 8, would appear to represent *L. moderata*	1526. *Hyssia griseipennis* Feld., vol. 5, p. 278. ¶.

† This is placed by Hampson in the *Hypsidae*, but it is taken here for convenience. *Nyctemera* is now restricted to certain African moths formerly called *Otroeda*, now placed in the *Lymantriidae*.

‡ Hampson has recently given the generic name *Miselia* Tr. priority over *Polia* Tr. With the imperfect material at his disposal when writing his catalogue he considered the North and South Island forms sexes of White's species. The type in the national collection is the same insect as Meyrick's *rhodopleura*, so that name sinks. The description in the catalogue requires correction owing to the confusion of the two species. See Ann. Mag. Nat. Hist. (8), viii, p. 421 (1911).

Hyssia inconstans Butl., Huds. p. 9, included under *L. griseipennis*
Leucania temenaula Meyr., Trans. N.Z. Inst. 1907, vol. 39, p. 106
Melanchra cucullina Guen., Huds. p. 27, v, 23
Leucania pachyscia Meyr., Trans. N.Z. Inst. 1907, vol. 39, p. 106.
Leucania moderata Walk., Huds. p. 9, ? iv, 8
Hyssia sminthistis Hmpsn., Wellington list
Leucania nullifera Walk., Huds. p. 9, iv, 9
Melanchra plena Walk., Huds. p. 17, iv, 32

Melanchra insignis Walk., Huds. p. 16, iv, 29, 30
Melanchra mutans Walk., Huds. p. 18, iv, 34, 35, 36
Melanchra caeleno Huds., Huds. p. 26, iv, 39.
Melanchra beata Howes, Trans. N.Z. Inst. 1906, vol. 38, p. 511, xliv, 2
Melanchra levis Philpott, Trans. N.Z. Inst. 1905, vol. 37, p. 329, xx, 4
Melanchra paracausta Meyr., Huds. p. 15, iv, 28, 28A

Melanchra maya Huds., Huds. p. 17, iv, 31

Melanchra bromias Meyr., Trans. Ent. Soc. Lond. 1902, p. 273
Melanchra agorastis Meyr., Huds. p. 18, v, 30
Melanchra proteastis Meyr., Huds. p. 20, iv, 40
Melanchra infensa Walk., Huds. p. 23, v, 12
Melanchra rubescens Butl., Huds. p. 25, v, 18
Melanchra ustistriga Walk., Huds. p. 26, v, 20, 20A
Melanchra lithias Meyr., Huds. p. 17, iv, 33
Melanchra homoscia Meyr., Huds. p. 21, v, 7
Melanchra stipata Walk., Huds. p. 25, v, 17
Melanchra alcyone Huds., Huds. p. 24, v, 14
Leucania alopa Meyr., Huds. p. 12, iv, 16
Melanchra merope Huds., Huds. p. 19, v, 2

1527. *Hyssia inconstans* Butl. (3), vol. 5, p. 279, lxxxv, 23.
(1527A.) *Hyssia temenaula* Meyr. (1). ¶.

1528. *Hyssia cucullina* Guen. (4), vol. 5, p. 279, lxxx, 27.
(1528A.) *Hyssia pachysia* Meyr. (0). ¶.

1529. *Hyssia moderata* Walk., vol. 5, p. 280; fig.
1530. *Hyssia sminthistis* Hmpsn. (1), vol. 5, p. 280, lxxxvi, 17.
1531. *Hyssia nullifera* Walk. (3), vol. 5, p. 281; fig.
1671. *Morrisonia plena* Walk., vol. 5, p. 367. ¶
(1671A.) *Morrisonia chlorodonta* Hmpsn. (1 ♀). ¶. Description in Ann. Mag. Nat. Hist. (8), viii, p. 423 (1911).
1672. *Morrisonia insignis* Walk., vol. 5, p. 368, lxxxviii, 20.
1673. *Morrisonia mutans* Walk., vol. 5, p. 369, lxxxviii, 21.
(1673A.) *Morrisonia caeleno* Huds. (1 ♀) [vol. 5, p. 612, *ignot.*].
(1673B.) *Morrisonia beata* Howes (1). ¶.

(1673C.) *Morrisonia levis* Philpott (2 ♀). ¶.
* 1674. *Morrisonia paracausta* Meyr. (6), vol. 5, p. 370. ¶.
(1674A.) *Morrisonia oliveri* Hmpsn. (1 ♀). ¶. Description in Ann. Mag. Nat. Hist. (8), viii, p. 424 (1911).
(1674B.) *Morrisonia maya* Huds. (1) [vol. 5, p. 612, *ignot.*].
(1674C.) *Morrisonia chyserythra* Hmpsn. (1). ¶.
* 1675. *Morrisonia bromias* Meyr. (0), vol. 5, p. 370, lxxxviii, 22.
* 1676. *Morrisonia agorastis* Meyr. (0). vol. 5, p. 371, lxxxviii, 23.
1682. *Morrisonia vitiosa* Butl. (3), vol. 5, p. 375. ¶.
1683. *Morrisonia infensa* Walk. (1 ♀), vol. 5, 376, lxxxviii, 27.†
1684. *Morrisonia rubescens* Butl., vol. 5, p. 376, lxxxviii, 28.
1685. *Morrisonia ustistriga* Walk., vol. 5, p. 377, lxxxviii, 29.
* 1686. *Morrisonia lithias* Meyr. (0), vol. 5, p. 378. ¶.
1687. *Morrisonia homoscia* Meyr. (5), vol. 5, p. 378, lxxxviii, 23.
1688. *Morrisonia stipata* Walk., vol. 5, p. 379; fig.
(1688A.) *Morrisonia alcyone* Huds. (1) [vol. 5, p. 612, *ignot.*].
(1688B.) *Morrisonia alopa* Meyr. (3) [vol. 5, p. 611, *ignot.*].
(1688C.) *Morrisonia merope* Huds. (1) [vol. 5, p. 612, *ignot.*].‡

† The male of this species is not known to Hampson, who thinks it likely to come near *Alopa*.

‡ I found this in the British Museum as *M. chlorographa*, so described by Hampson in Ann. Mag. Nat. Hist., 1905, p. 452, but he has since sunk that name.

Melanchra diatmeta Huds., Huds. p. 21, v, 5

Melanchra dotata Walk., Huds. p. 24, v, 16

Melanchra vitiosa Butl., Huds. p. 20, iv, 42

Melanchra tartarea Butl., Huds. p. 21, v, 6

Melanchra omoplaca Meyr., Huds. p. 23, v, 13

Melanchra decorata Philpott, Trans. N.Z. Inst. 1905, vol. 37, p. 328, xx, 2

Melanchra lignana Walk., Huds. p. 26, v, 19

Melanchra pelistis Meyr., Huds. p. 19, v, 3, 4

Melanchra prionistis Meyr., Huds. p. 27, v, 21

Leucania temperata Walk., Huds. p. 9. ¶

Melanchra phricias Meyr., Huds. p. 27, v, 22

Melanchra composita Guen., Huds. p. 22, v, 8, 9

Leucania arotis Meyr., Huds. p. 12, iv, 18

Leucania innotata Howes, Trans. N.Z. Inst. 1908, vol. 40, p. 534

Melanchra steropastis Meyr., Huds. p. 23, v, 10, 11

Leucania atristriga Walk., Huds. p. 10, iv, 12

Physetica caerulea Guen., Huds. p. 8, iv, 7

Leucania micrastra Meyr., Huds. p. 12, iv, 10

Melanchra disjungens Walk., Huds. p. 15, v, 43

Leucania propria Walk., Huds. p. 11, iv, 13

Leucania unipuncta Haw., Huds. p. 13, iv, 24

Ichneutica ceraunias Meyr., Huds. p. 14, iv, 25, 26

Ichneutica dione Huds., Huds. p. 14, iv, 27

Leucania acontistis Meyr., Huds. p. 11, iv, 14

Leucania toroneura Meyr., Trans. Ent. Soc. Lond. 1901, p. 565

Leucania neurae Philpott, Trans. N.Z. Inst. 1905, vol. 37, 330, xx, 5

Leucania unica Walk., Huds. p. 12, iv, 17

(1688D.) *Morrisonia diatmeta* Huds. (1 ♀). ¶.

1689. *Morrisonia dotata* Walk. (1), vol. 5, p. 380, lxxxviii, 31.

1690. *Morrisonia ochthistis* Meyr., vol. 5, p. 380, lxxxviii, 32.

1691. *Morrisonia tartarea* Butl. (3), vol. 5, p. 381, lxxxix, 1.

1692. *Morrisonia omoplaca* Meyr. (1), vol. 5, p. 382, lxxxix, 2.

(1693A.) *Morrisonia decorata* Philpott (4). ¶.

1694. *Morrisonia lignana* Walk., vol. 5, p. 383, lxxxix, 3.

1695. *Morrisonia morosa* Butl., vol. 5, p. 384, lxxxix, 4.

* 1696. *Morrisonia prionistis* Meyr. (6), vol. 5, p. 384, lxxxix, 5.

1697. *Morrisonia temperata* Walk. (5), vol. 5, p. 385, lxxxix, 6.

1698. *Morrisonia phricias* Meyr., vol. 5, p. 385, lxxxix, 7.

(1698A.) *Morrisonia longstaffi* Howes, Trans. N.Z. Inst. 1911, vol. 43, p. 128; fig.

(1698B.) *Morrisonia sequens* Howes, Trans. N.Z. Inst. 1912, vol. 44, p. 204; fig.

1699. *Persectania evingi* Westw., vol. 5, p. 386; fig.

1700. *Persectania aulacias* Meyr. (2), vol. 5, p. 387, lxxxix, 8. Syn. *arotis* Meyr.; syn. *obsoleta* Howes; syn. *innotata* Howes.

1701. *Persectania steropastis* Meyr., vol. 5, p. 388, lxxxix, 9.

1702. *Persectania atristriga* Walk., vol. 5, p. 388; fig.

1786. *Physetica caerulea* Guen. (5), vol. 5, p. 445; fig.

1787. *Physetica vindimialis* Guen. (1), vol. 5, p. 445, xci, 2. Hampson says, "Hab. (?) U.S.A., E. Florida (Doubleday). 1 ♀ type. The type has the abdomen of a male of some other species stuck on to it, and will probably prove to be from New Zealand." Vol. 5, p. 446.

* 1788. *Physetica micrastra*. Meyr. (0), vol. 5, p. 446, xci, 3.

1816. *Graphania disjungens* Walk., vol. 5, p. 469; fig.

1818. *Tmetolophota propria* Walk., vol. 5, p. 471; fig.

1915. *Cirphis unipuncta* Haw., vol. 5, p. 547. ¶.

* 2036. *Leucania ceraunias* Meyr. (3), vol. 5, p. 590.

* 2037. *Leucania dione* Huds. (0), vol. 5, p. 590. ¶.

(2037A.) *Leucania acontistis* Meyr. (3) [vol. 5, p. 610, *ignot.*].

* 2038. *Leucania toroneura* Meyr. (1), vol. 5, p. 591, xcvi, 1. Syn. *Leucania neurae* Philpott.

2039. *Leucania unica* Walk. (5), vol. 5, p. 591; fig.

Leucania dunedinensis Butl. ¶ ..	2040. *Leucania dunedinensis* Hmpsn. (2), vol. 5, p. 591, xcvi, 2.
Leucania semivittata Walk., Huds. p. 13, iv, 21, 22	2041. *Leucania semivittata* Walk. (5), vol. 5, p. 592; fig.
Leucania blenheimensis Fereday, Huds. p. 13, iv, 23	* 2042. *Leucania blenheimensis* Fereday (0), vol. 5, p. 592, xcvi, 3.
Leucania purdii Fereday, Huds. p. 10, iv, 11	(2042A.) *Leucania purdiei* Fereday (1) [vol. 5, p. 611, *ignot.*].
Leucania sulcana Fereday, Huds. p. 13, iv, 19, 20	2043. *Leucania sulcana* Fereday (5), vol. 5, p. 593; fig.
Miselia pessota Meyr., Huds. p. 6, v, 26	* 2606. ? *Sympistis pessota* Meyr. (0), vol. 6, p. 412, *ignot.*
Miselia iota Huds., Trans. N.Z. Inst. 1903, vol. 35, p. 243, xxx, 3	* 2607. *Sympistis iota* Huds. (0), vol. 6, p. 413, *ignot.*
Orthosia fortis Butl., Meyr. Trans. Ent. Soc. Lond. 1901, p. 565	2608. *Sympistis fortis* Butl. (2), vol. 6, p. 413; fig.
Xanthia purpurea Butl., Huds. p. 8, v, 32	2715. *Austramathes purpurea* Butl., vol. 6, p. 492; fig.
Bityla defigurata Walk., Huds. p. 29, v, 33	2775. *Bityla defigurata* Walk., vol. 7, p. 41; fig.
Bityla sericea Butl., Huds. p. 29, v, 31	2776. *Bityla sericea* Butl. (1), vol. 7, p. 41. ¶.
Orthosia pallida Huds., Trans. N.Z. Inst. 1905, vol. 36, p. 355	2777. ? *Bityla pallida* Huds. (1), vol. 7, p. 42, cix, 6.
Cosmodes elegans Donov., Huds. p. 33, vi, 2	3591. *Cosmodes elegans* Donov., vol. 8, p. 17; fig.
Orthosia comma Walk., Huds. p. 7, v, 27, 28	4071. *Ariathisa comma* Walk., vol. 8, p. 400; fig.
Plusia chalcites Esp., Huds. p. 35, vi, 3 ..	*Plusia chalcites* Esp.
Dasypodia selenophora Guen., Huds. p. 35, vi, 4	
Hypenodes exsularis Meyr., Huds. p. 34. ¶	*Hypenodes exsularis* Meyr. (0).
Hyperaucha octias Meyr., Huds. p. 37, vi, 7	*Hypenodes anticlina* Meyr. (0).
(*Rhapsa octias*, Huds.) †	
Rhapsa scotosialis Walk., Huds. p. 36, vi, 5, 6	

Sir George Hampson has not seen any of the following thirteen species, the types of which would appear to be in New Zealand, consequently he is unable to give any definite opinion about them. His difficulty is the same as Mr. Hudson has often laboured under.

Agrotis veda Howes, Trans. N.Z. Inst. 1906, vol. 38, p. 511, xliv, 3	
Orthosia margarita Hawthorne, Huds. p. 6, v, 31	
Melanchra exquisita Philpott, Trans. N.Z. Inst. 1903, vol. 35, p. 246, xxxii, 2	Hmpsn., vol. 5, p. 612 (? near *Polia pictula*).
Melanchra omicron Huds., Huds. p. 22, v, 42	Hmpsn., vol. 5, p. 612 (? *Hyssia*, near *cucullina*).
Melanchra asterope Huds., Huds. p. 24, v, 15	Hmpsn., vol. 5, p. 612 (? *Morrisonia*, near *dotata*).
Melanchra grandiosa Philpott, Trans. N.Z. Inst. 1903, vol. 35, p. 246, xxxii, 1	Hmpsn., vol. 5, p. 612 (? *Morrisonia*).
Melanchra mollis Howes, Trans. N.Z. Inst. 1908, vol. 40, p. 533	
Melanchra octans Huds., Huds. p. 25, v, 1	Hmpsn., vol. 5, p. 612 (? *Xylomania*, near *natalensis*).
Melanchra erebia Huds., Subantarc. Is. N.Z. 1909, p. 68, ii, 15	

† Mr. Meyrick (Trans. Ent. Soc. Lond. 1901, p. 566) confesses to having led Mr. Hudson astray.

Leucania pagaia Huds., Subantarc. Is. N.Z., p. 67, ii, 9	
Physetica hudsoni Howes, Trans. N.Z. Inst. 1906, vol. 38, p. 510, xliv, 1	Mr. Howes agrees with Mr. Hamilton in regarding this as a form of *Physetica caerulea* Guen.; but Sir George, who has not seen the insect, thinks it may possibly be a form of *Hyssia griseipennis*.
Leucania stulta Philpott, Trans. N.Z. Inst. 1905, vol. 37, 329, xx, 1	
Leucania phaula Meyr., Huds. p. 11, iv, 15	Hmpsn., vol. 5, p. 611 (? near *L. blenheimensis*).

At this place in Mr. Hudson's book the group that is usually called the *Geometridae* follows. As Mr. L. B. Prout is still engaged in his great revision of this group for Wytsman's "Genera Insectorum" (of which one part has already appeared), it does not appear expedient to deal with them here systematically, but at the same time it may be convenient to mention three points :—

(1.) *Xanthorhoe cineraria* Dbld., Huds. p. 67, pl. viii, figs. 2, 2A.—Personally I have no doubt that the larger form is *semi-signata* Walk. (pl. viii, fig. 2A) and the smaller *cineraria* Dbld. (pl. viii, fig. 2), and that these constitute distinct species.

(2.) *Lythria euclidiata* Guen., Huds. p. 68, pl. viii, fig. 35.—My specimens referred by Mr. Howes to this species agree absolutely with Butler's type of *Arctesthes catapyrrha* (in the British Museum), an insect, in my opinion (and, I believe, in Mr. Prout's also), quite distinct from the Australian *euclidiata*.

(3.) *Sestra humeraria* Walk., Huds. p. 89, pl. x, figs. 1, 2; and *Sestra flexata* Walk., Huds. p. 90, pl. ix, fig. 37 (very poor figure).—Walker's types are in the British Museum, and I have compared them with his descriptions. There seems no room for doubt that, by some unfortunate slip, Mr. Hudson has reversed the two species.

In conclusion, I have a few remarks to make about the butterflies—

(1.) *Anosia erripus* Cram., Huds. p. 102, pl. xi, figs. 1, 2.—The synonomy of this species is extremely confusing. Dr. Jordan, who has gone into the matter very thoroughly, says that the genus *Anosia* Hübn. (and several of Moore's genera) are not really distinct from *Danaida* Latr., which has priority. It would be in accordance with the best modern usage to call the insect *Danaida archippus* Fab.

(2.) *Anosia bolina* Linn., Huds. p. 104, pl. xii, figs. 7, 8, 9.—This is, of course, not a Danaine, but a Nymphaline of the genus *Hypolimnas* Hübn.

(3.) *Vanessa cardui* Linn., Huds. p. 108, pl. xii, figs. 1, 2.—I quite agree with Mr. Hudson that the form *kershawi* McCoy does not merit specific rank. The Hope collection at Oxford contains a specimen from Cyprus, one from Mongolia, and three from Great Britain, with blue centres to the black spots on the hindwing. The section of the old genus *Vanessa* to which the three New Zealand species belong is now more commonly called *Pyrameis* Hübn.

(4.) *Junonia velleda* Fabr., Huds. p. 109, pl. xi, figs. 16, 17.—This is now referred to *Precis*. I agree with Mr. Hudson as to the spelling of the name : *vellida* is meaningless.

(5.) *Chrysophanus salustius* Fabr., Huds. p. 117, pl. xii, figs. 18, 19, 20, 21 ; pl. xiii, figs. 2, 3, 4, 5.—Surely this name should be *sallustius:* the other spelling is meaningless.

(6.) *Chrysophanus enysii* Butl., Huds. p. 117, pl. xii, figs. 22, 23, 24.—The types of *enysii* Butler and *feredayi* Bates are both in the British Museum. They are clearly conspecific, and Bates's name has priority. Mr. Hudson is in error in supposing *feredayi* to be a form of *sallustius.*

(7.) *Lycaena phoebe* Murray, Huds. p. 119, pl. xii, figs. 10, 11.—This is indistinguishable from *Zizera labradus* Godart, which has priority.

(8.) *Lycaena oxleyi* Feld., Huds. p. 119, pl. xii, fig. 12.—This was referred to *Zizera*, but has lately been placed in *Neolucia*, Waterhouse and Turner.

Art. VIII.—*Descriptions of Three New Species of* Lepidoptera.

By Alfred Philpott.

Communicated by Professor Benham.

[*Read before the Otago Institute, 3rd October, 1911.*]

Hydriomenidae.

Chloroclystis lunata n. sp.

♂. 18–19 mm. Head, palpi, thorax, and abdomen dark greenish-fuscous. Palpi 1½. Antennae biciliated with long fascicles, ciliations 3. Forewings triangular, costa almost straight, termen slightly bowed, subsinuate on lower half ; *dark greenish-fuscous ;* veins marked more or less with black ; lines obscure ; some faint thin waved green lines near base ; median band ochreous except beneath costa, anterior edge from ½ to ⅗, waved, hardly curved, posterior from ¾ to ⅘, bluntly projecting at middle and concave on lower half ; a thin dentate bluish-green subterminal line : cilia ochreous, barred with fuscous. Hindwings fuscous, sprinkled with ochreous ; veins with alternate black and white dots ; a thin dentate bluish-green subterminal line.

♀ as ♂, but median band almost obsolete, and *with prominent irregular crescentic white mark in middle of forewing*, the limbs directed posteriorly.

Wallacetown, in December and January. A reddish-brown larva found feeding on *Veronica* on the 5th February pupated a few days later and emerged as a ♀ moth early in the following December. Unfortunately a fuller description of the larva was not secured.

The species differs from most of its allies in its darker ground-colour, and in the ♀ the white crescentic mark is a good distinctive character.

CRAMBIDAE.

Orocrambus subitus n. sp.

♂. 15–16 mm. Head dark brownish-fuscous. Palpi dark brownish-fuscous, whitish above. Antennae fuscous. Thorax dark brownish-fuscous with white lateral stripe. Abdomen dark brownish-fuscous. Forewings, costa straight, apex obtuse, termen slightly oblique, golden brown sprinkled with white scales, densely irrorated with white in disc and along dorsum, white irroration produced as a streak from disc to apex, dorsum narrowly black from base to $\frac{1}{3}$; a thick black central streak from base to $\frac{1}{2}$, *apex obtuse*, margined beneath with golden brown; a short black streak above apex of basal streak, *anteriorly tapered;* a few black scales before tornus indicating a black subterminal line: cilia dark golden brown with obscure darker line. Hindwings dark brownish-fuscous; cilia brown, paler round tornus.

♀. Forewings with *white irroration extending to costa;* black streaks as in ♂, *but margined with orange:* cilia grey mixed with white. Hindwings, grey, paler round termen; cilia grey.

Hump Ridge (Okaka); fairly common at 3,500 ft. in December.

Nearest to *O. thimiastis*, but differing from that species in the colour of the streaks in disc, which are white or yellow in *thimiastis*, black in *subitus*.

PYRAUSTIDAE.

Scoparia clavata n. sp.

♂. 26 mm. Head and thorax white, with a black lateral stripe from eye to near middle of thorax. Palpi moderate, white above, sides and beneath dark-brownish. Antennae and abdomen grey. Legs grey, anterior pair suffused with fuscous. Forewings moderate, posteriorly dilated, costa almost straight, apex rounded, termen subsinuate, oblique; white, irrorated with brownish-ochreous, costa narrowly brownish; a thick black median streak from base of costa to almost $\frac{1}{2}$, slightly constricted near termination, apex rounded; a thick black streak in disc above middle, irregularly sinuate, beginning before $\frac{1}{3}$ and ending at about $\frac{2}{3}$ in irregular dilatation; *a subterminal black striga, inwardly oblique and dilated beneath costa and above dorsum;* all streaks margined with brownish-ochreous; a terminal chain of linear black dots: cilia whitish with two grey lines. Hindwings shining white, ochreous round termen; cilia white, ochreous near apex.

Hump Ridge; in forest, at 3,000 ft., in December; one specimen.

Easily distinguished from *S. rotuella*, its nearest ally, by the subterminal black strigae; it is also broader-winged than that species.

Art. IX.—*Descriptions of New Zealand* Lepidoptera.

By E. Meyrick, B.A., F.R.S.

[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

I am again enabled by the kindness of Messrs. G. V. Hudson and A. Philpott to present descriptions of a further series of new species of *Lepidoptera*, representing the results of their labours during the past season. These include some forms of remarkable interest.

Caradrinidae.

Melanchra xanthogramma n. sp.

♂. 37 mm. Head and thorax reddish-brown mixed with whitish-ochreous, sides of patagia and ridge of collar streaked with black and whitish irroration. Antennae bipectinated (*a* 2, *b* 1½), apical third simple, ciliated. Abdomen fuscous, sides and apex tufted with reddish-brown scales mixed with whitish-ochreous. Forewings elongate-triangular, costa slightly arched, apex obtuse, termen rather obliquely rounded, crenulate; light reddish-brown; subbasal, first, and second lines waved, indicated by interrupted edgings of black irroration, lower end of subbasal connected with base by a bent dark red-brown and blackish mark surmounted with yellow, second obsolete from near costa to below reniform; an elongate-oval suffused yellow spot beneath submedian fold between subbasal and first lines, and a streak of yellow suffusion along dorsum from ¼ to ¾; spots darker reddish-brown, edged with yellow and then with blackish, orbicular short-oval, rather oblique, somewhat paler-centred, claviform rather smaller, roundish, anteriorly defined by first line, reniform with posterior half pale and whitish-mixed; space between these darker, with some yellow and blackish scales; a dark-fuscous elongate patch extending from second to subterminal lines above submedian fold; some whitish suffusion towards dorsum beneath this; three whitish dots on costa between second and subterminal lines; subterminal line slender, yellow, straight and edged with blackish posteriorly, towards extremities dentate and unmargined, at ¼ with a dilatation, below middle with a very abrupt acute double dentation reaching termen; a terminal series of lunulate blackish marks: cilia reddish-brown mixed with paler and whitish. Hindwings fuscous; cilia whitish, basal half fuscous.

Wellington (Hudson); one specimen. At first sight much like a variety of *insignis*, but (as Mr. Hudson correctly points out) the antennal pectinations in that species are somewhat longer. An easy distinction is afforded by the absence of the well-defined short black basal streak of *insignis*.

Selidosemidae.

Selidosema lactiflua n. sp.

♂. 36 mm. Head and thorax olive-greenish mixed with yellow-whitish. Antennal pectinations, *a* 6, *b* 5; about 8 apical joints simple. Abdomen whitish-yellowish. Forewings triangular, costa slightly arched,

apex rounded-obtuse, termen evenly rounded, rather oblique; 10 and 11 separate; olive-greenish, sprinkled with blackish; costal area strigulated with white from $\frac{1}{4}$ to $\frac{3}{4}$; lines formed by blackish suffusion, first and second double, waved, first somewhat curved, second slightly and rather irregularly curved, somewhat sinuate inwards towards dorsum, median thick, somewhat curved; a blackish transverse discal mark beyond median line; second line followed by a white band strigulated with olive-greenish; subterminal line slender, waved, white, preceded and followed by blackish suffusion tending to form spots; a terminal series of black lunulate marks: cilia pale olive-greenish, sometimes sprinkled with blackish, narrowly and obscurely barred with white. Hindwings whitish-yellow-ochreous, towards dorsum and termen sometimes finely and slightly sprinkled with grey; a grey discal dot, sometimes faint; a terminal series of slight dark-grey marks; cilia whitish-ochreous-yellow.

Lake Wakatipu (Hudson), in February; two specimens. A fine distinct species, resembling *melinata* and *leucelaea*.

Crambidae.

Orocrambus pervius n. sp.

♂. 25 mm. Head, palpi, and thorax dark fuscous, palpi mixed beneath with whitish hairs, shoulder with a slight white mark. Antennae shortly ciliated ($\frac{1}{3}$). Abdomen dark grey, apex whitish. Forewings elongate, posteriorly dilated, costa hardly arched, apex obtuse, termen rounded, somewhat oblique; dark fuscous, irregularly strewn or partially suffused with ochreous-brown scales; costal edge slenderly whitish on median area; a rather narrow white median longitudinal streak from base to termen, beyond middle shortly attenuated or interrupted: cilia grey, with a white bar on median streak. Hindwings dark grey, pectinations ochreous-whitish; cilia ochreous-whitish, basal third grey. Hindwings beneath largely suffused with ochreous-whitish.

Lake Wakatipu, 3,600 ft. (Hudson), in February; two specimens. Closely allied to *catacaustus*, which, however, is browner, with a white shoulder-stripe (not mentioned in my description), and with the median stripe only seldom showing a tendency to interruption; but the reliable distinguishing character lies in the form of the forewings, of which in *catacaustus* the termen is not oblique on the upper portion.

Pyraustidae.

Scoparia triscelis Meyr.

This distinct species, originally described from Auckland Island ("Subantarctic Islands of New Zealand," p. 71), has now been found by Mr. Hudson at Lake Wakatipu; a very interesting observation.

Scoparia locularis n. sp.

♂. 21 mm. Head ochreous-whitish. Palpi $2\frac{2}{3}$, dark fuscous, basal joint white. Antennal ciliations $\frac{2}{3}$. Thorax white mixed with grey and dark fuscous. Abdomen grey. Forewings elongate-triangular, narrow at base, costa posteriorly moderately arched, apex obtuse, termen sinuate, oblique; light grey, irregularly mixed with white, with some scattered black scales; an oblique streak of black suffusion from base of costa; first line white, rather oblique, slightly sinuate, posteriorly strongly edged with black suffusion; orbicular and claviform represented by elongate marks

of black suffusion connected with this: discal spot 8-shaped, outlined with black, upper half larger but less defined, connected with costa by a spot of black irroration; second line slender, irregular, white, anteriorly interruptedly edged with black, slightly curved, indented beneath costa and more strongly on submedian fold; subterminal suffused, whitish, strongly sinuate inwards in middle to touch second line and more or less interrupted above the connection, the sinuation filled with a spot of blackish suffusion: cilia pale fuscous, with blackish ante-median and fuscous post-median lines, broadly barred with whitish. Hindwings $1\frac{1}{4}$, without hairs in cell; pale grey, becoming darker posteriorly; discal mark and post-median line faintly darker; cilia grey-whitish, with interrupted dark-fuscous subbasal line.

Mount Arthur, 3,400 ft., and Lake Wakatipu (Hudson), in January and February; two specimens. Allied to *torodes*.

Scoparia agana n. sp.

♂. 23–25 mm. Head white. Palpi 3, rather dark fuscous, basal joint white. Antennal ciliations $\frac{1}{2}$. Thorax purplish-grey. Abdomen pale greyish-ochreous. Forewings elongate, narrow at base, posteriorly dilated, costa posteriorly gently arched, apex obtuse, termen straight, rather oblique; fuscous, irregularly mixed with white; indistinct streaks of dark-fuscous irroration along fold from base to first line, and posteriorly between veins; lines formed of white suffusion, first curved, oblique, second rather curved, indented beneath costa and above dorsum; orbicular and claviform represented by indistinct longitudinal marks of dark-fuscous suffusion resting on first line; discal mark obscurely X-shaped, formed by blackish irroration, lower half filled with whitish suffusion; subterminal line broad, suffused, whitish, almost terminal, rather sinuate inwards in middle but not reaching second line: cilia grey-whitish, with interrupted grey ante-median line. Hindwings $1\frac{1}{3}$, without hairs in cell; grey-whitish, with brassy-yellowish reflections; cilia yellow-whitish.

Lake Wakatipu, in February (Hudson); one specimen. A second taken by myself on Arthur's Pass, at 3,000 ft., in January. Allied to *crypsinoa*.

PTEROPHORIDAE.

Stenoptilia vigens Feld.

Oxyptilus vigens Feld., Reis. Nov., pl. cxl, 49.

♀. 19 mm. Head pale brownish, sides whitish, face prominent. Palpi $2\frac{1}{2}$, ochreous-brown, lower edge whitish towards base. Thorax ochreous-white, suffused with light brownish anteriorly. Abdomen whitish-ochreous, towards base white. Forewings cleft to $\frac{3}{4}$, segments rather broad, apex pointed, termen oblique, on second segment slightly bowed; reddish-brown, suffusedly mixed with whitish in disc, with a broad streak of white suffusion along dorsum, dorsal edge tinged with reddish-ochreous; costa suffused with dark fuscous, dotted with whitish from base to beyond middle; a dark red-brown spot mixed with black on base of cleft, above which is a patch of white suffusion not quite reaching costa; posterior area of first segment occupied by a blotch of darker red-brown suffusion mixed with black, marked with a bar of white suffusion close before termen; second segment somewhat sprinkled with whitish posteriorly: cilia on costa dark fuscous, on termen and in cleft white, with a small blackish patch at lower angle of first segment and upper angle of second, and a

blackish basal line on termen of second segment; cilia round tornus and on dorsum fuscous. Hindwings rather dark fuscous; cilia grey, base grey-whitish.

Lake Wakatipu (Hudson), in February. This is an interesting rediscovery, as Felder's species had never been recognized before, and his localities are frequently quite erroneous. It is allied to *charadrias*.

Stenoptilia zophodactyla Dup.

Mr. Hudson sends a specimen of this nearly cosmopolitan species, taken near Wellington in November, stating it to be very rare. It has not been previously recorded from New Zealand. It is common in Europe, which is probably its place of origin; but I have also received it freely from India, Australia, South Africa, and South America. The larva feeds on *Erythraea*, but must also be attached to other *Gentianaceae*, and is probably artificially introduced. It may have reached New Zealand only quite recently.

Carposinidae.

Carposina morbida n. sp.

♂. 26 mm. Head ochreous-whitish. Palpi $2\frac{1}{2}$, porrected, ochreous-whitish, basal half suffused with dark olive-grey. Antennal ciliations 4. Thorax ochreous-whitish, shoulders with an ochreous spot. Abdomen ochreous-whitish. Forewings elongate, rather narrow, posteriorly somewhat dilated, costa gently arched, apex obtuse, termen straight, rather oblique; silvery-whitish-ochreous, irregularly strewn with ochreous scales, costa and dorsum somewhat sprinkled with grey; a small brownish-ochreous basal patch, edge parallel to termen; six small shots of grey suffusion on costa between this and apex; tufts brownish-ochreous, posteriorly white—viz., one beneath costa at $\frac{1}{3}$, preceded by a dash of black irroration, one beneath this towards dorsum, a larger one in disc beyond these, preceded by a black dash on submedian fold, two towards costa in and beyond middle edged with black beneath, one below middle edged with black above, and a ridge on transverse vein, irregularly edged with black anteriorly, between these in middle of disc is an elongate patch of grey suffusion; some scattered black irroration crossing wing at $\frac{5}{6}$; cilia whitish, with two greyish shades. Hindwings and cilia whitish. Under-surface of forewings and hindwings largely clothed on anterior half with modified pale yellow-ochreous scales, on forewings anteriorly suffused with grey.

Lake Wakatipu (Hudson), in February; one specimen. Can only be confused with *exochana;* but the ♂ of that species has much longer porrected palpi (4).

Tortricidae.

Harmologa tritochlora n. sp.

♀. 22 mm. Head and palpi pale ochreous, palpi 3. Thorax whitish-ochreous, patagia suffusedly mixed with grey. Abdomen ochreous-whitish. Forewings elongate-oblong, costa moderately arched towards base, thence nearly straight, apex obtuse, termen slightly rounded, somewhat oblique; whitish-grey suffused with pale brassy-yellowish, becoming whitish-yellowish towards costa and termen, irrorated with darker grey on dorsal half towards base: cilia whitish-yellowish. Hindwings and cilia creamy-white.

Lake Wakatipu, 4,000 ft. (Hudson), in February; one specimen. Allied to *siraea* and *aenea*, but cannot be united with either; doubtless the ♂, as in those species, is very different, with dark hindwings.

Oecophoridae.

Izatha metadelta Meyr.

Mr. Hudson suggests that *percnitis* Meyr. is the ♂ of this species, and on consideration of the available material, having now several specimens of each form, all the *percnitis* being ♂ and all the *metadelta* ♀, I have no doubt his view is correct, and they must be united as sexes.

Glyphipterygidae.

Simaethis zomeuta n. sp.

♀. 18 mm. Head and thorax bronzy-brown, sprinkled with whitish. Palpi with whorls of blackish white-tipped scales, base white. Antennae dark fuscous dotted with white. Abdomen dark fuscous. Forewings elongate, posteriorly dilated, costa gently arched, apex obtuse, termen bowed, rather oblique; bronzy-ochreous-fuscous; some violet-white irroration towards base and termen; a moderately broad darker median transverse fascia, angulated above middle, edged by obscure shades of violet-white irroration, becoming more distinct on costa, where the second forms a clear white oblique mark: cilia bronzy-ochreous, with two dark-fuscous shades, and white patches on outer half above and below middle. Hindwings bronzy-fuscous, becoming blackish on posterior half; a rather incurved white streak crossing dorsal half of wing from $\frac{3}{4}$ of disc to tornus, and some whitish irroration between this and termen; cilia whitish, basal third dark fuscous.

Mount Arthur, 4,600 ft.; one specimen taken by myself in January, not in fine condition, but twenty-five years have passed without further captures. Near *combinatana*, but distinguishable by clear white streak of hindwings, and the joints of antennae are relatively much more elongate and slender.

Simaethis ministra n. sp.

♂. 9 mm. Head dark fuscous, face sprinkled with white. Palpi with whorls of dark-fuscous white-tipped scales, base white. Antennae dark fuscous, shortly pubescent-ciliated. Thorax dark fuscous. Abdomen dark fuscous, segmental margins partially white. Forewings suboblong, costa moderately arched anteriorly, apex obtuse, termen slightly rounded, somewhat oblique; dark bronzy-fuscous; five very undefined irregular transverse shades of white irroration, first three rather curved or bent, fourth forming a clear white spot on costa beyond middle and then a fine silvery quadrangular loop passing behind a transverse linear discal mark of white irroration, fifth straight, interrupted above middle; two or three silvery-metallic scales before termen above middle: cilia white with dark-fuscous shade (imperfect). Hindwings light fuscous, becoming darker towards termen; dorsal half with scattered white scales; a well-marked irregular white streak extending across dorsal half of wing from disc at $\frac{3}{4}$ nearly to tornus, its lower half approximated to termen; cilia white, with fuscous subbasal and post-median shades.

Mount Holdsworth (Hudson); one specimen. This and the two following species are closely allied and very similar, agreeing together in

having the antennae of ♂ shortly pubescent-ciliated, whilst in *S. marmarea*, which is also very similar superficially, they are ciliated with long fascicles (3), as is usual in the genus. *S. ministra* differs from the other two in having the antennae wholly dark fuscous, the forewings obviously broader anteriorly, with costa more arched than in either of the others, the white markings of forewings less defined, the white streak of hindwings broader and more irregular, reaching termen at ¾ from apex and continued almost to tornus.

Simaethis microlitha Meyr.

♂♀. 9–10 mm. Head and thorax irrorated with white above; scales of palpi longer and more projecting than in *analoga;* antennae dotted with white; abdomen with segmental margins strongly white. Forewings more narrowed towards base than in *ministra*, fasciae of white irroration more strongly marked, fourth slender, but more sharply marked and brightly silvery-metallic above discal mark and at apex of dorsal section. Hindwings with white streak slender, regular, well-marked, extending ¾ across wing from ¾ of disc to middle of termen and thence running partially interrupted near termen almost to tornus.

Arthur's Pass, 3,000 ft., in January; two specimens. In my description of this species I included also the following, which I now separate from it, and therefore specify the more characteristic points which distinguish the true *microlitha* from the preceding and following species; the character of the marking of hindwings is the most obvious of these.

Simaethis analoga n. sp.

♂♀. 8–9 mm. Head dark fuscous, face and sides of crown irrorated with white. Palpi with whorls of dark-fuscous white-tipped scales, base white. Antennae dark fuscous dotted with white, in ♂ shortly pubescent-ciliated. Thorax dark fuscous, somewhat sprinkled with white, inner edge of patagia white. Abdomen dark fuscous, segmental margins strongly white. Forewings rather elongate-triangular, costa gently arched, apex obtuse, termen slightly rounded, somewhat oblique; dark bronzy-fuscous; three curved cloudy transverse lines of white irroration on anterior half, two posterior sometimes irregularly confluent; a white line beyond middle forming a quadrangular loop behind a transverse-linear white discal mark, upper side of loop silvery-metallic, lower absent, a silvery-metallic dot on upper extremity of dorsal segment; a straight cloudy line of white irroration from ⅘ of costa to tornus, interrupted above middle; a transverse silvery-metallic mark before termen above middle: cilia white with two thick dark-fuscous lines, and dark patches at apex, middle of termen, and tornus. Hindwings fuscous, becoming dark fuscous posteriorly; a very short white detached transverse mark before middle of termen, and sometimes a dot on tornus; cilia white, with two thick dark-fuscous lines.

Mount Arthur, 4,000 ft., in January; ten specimens. As explained above, I originally regarded this as a form of *microlitha*, but now think it distinct. Doubtless more species of this group will be discovered in the mountains, and an attempt should be made to ascertain their food-plants.

Ereunetis acrodina n. sp.

♀. 14 mm. Head whitish-ochreous, hairs of forehead slightly mixed with dark fuscous. Antennae grey-whitish, basal joint with a blackish

spot. Palpi whitish, second joint streaked with dark fuscous above and beneath, terminal joint dark fuscous towards base. Thorax whitish-ochreous, shoulders with a dark-fuscous spot. Abdomen ochreous-whitish. Forewings elongate, narrow, costa moderately arched; apex round-pointed, upturned, termen extremely obliquely rounded; greyish-ochreous, with a few dark-fuscous scales; markings fuscous mixed with blackish; four oblique patches from costa, more or less confluent with a broad irregular submedian streak from near base to apex, first near base, second broadest, before middle, third narrow, fourth reduced to a streak; an irregular dark-fuscous apical spot surrounded with white: cilia whitish, with an interrupted black subbasal line, and fuscous post-median line, tips fuscous at apex. Hindwings grey-whitish; cilia whitish, at apex with two dark-grey lines.

Wellington (Hudson); one specimen. Intermediate between *erebistis* (which has hitherto stood rather isolated) and *fulguritella*.

Taleporia Hb.

The genus *Taleporia* has not previously been identified from the Southern Hemisphere, but the following species agrees fully with it, except that veins 7 and 8 of the forewings are separate, whereas in the typical European species they are stalked; in this group, however, this character is of little importance, and I have no hesitation in regarding the species as a true *Taleporia*, a very interesting discovery.

Taleporia aphrostcha n. sp.

♂ 22 mm. Head, palpi, and antennae dark fuscous, antennal ciliations 2½. Thorax dark fuscous, with several whitish dots posteriorly. Abdomen dark grey, somewhat whitish-mixed. Forewings elongate, rather narrow at base, posteriorly dilated, costa gently arched, apex obtuse, termen obliquely rounded; all veins separate; white, mixed with grey in disc and towards costa, coarsely reticulated throughout with dark fuscous; the white colour forms a more conspicuous quadrate spot on dorsum before middle, including a dark-fuscous dorsal strigula, and preceded and followed by irregular dark-fuscous spots: cilia fuscous, basal half spotted with white. Hindwings dark grey; cilia fuscous.

♀ apterous, active.

Hump Ridge, Invercargill, 3,500 ft. (Philpott); a pair in December.

HEPIALIDAE.

Porina copularis n. sp.

♂ 38–40 mm., ♀ 44–50 mm. Head and thorax pale ochreous, sometimes partially tinged with fuscous. Antennae in ♂ shortly bipectinated with flattened-wedge-shaped teeth. (2). Abdomen pale ochreous, in ♀ infuscated except anal tuft. Forewings formed nearly as in *umbraculata*, but costa more sinuate; pale ochreous, in ♀ tinged with fuscous; a white dot finely edged with dark fuscous in disc at ⅓, and an elongate mark beyond middle; in ♂ sometimes a smaller dot beneath submedian fold rather beyond first; a faint pale irregular sinuate transverse shade at ⅔, sometimes marked with a few indistinct fuscous strigulae, and sometimes a series of indistinct fuscous dots beyond this: cilia whitish-ochreous, barred with ochreous or greyish-ochreous. Hindwings pale fuscous tinged with ochreous; cilia as in forewings.

West Plains, Invercargill (Philpott); five specimens.

Porina jocosa n. sp.

♂ 40–44 mm., ♀ 44–51 mm. Head and thorax varying from light fuscous or brownish-ochreous to dark fuscous, posterior extremity of thorax sometimes whitish. Antennae in ♂ shortly bipectinated with flattened-wedge-shaped teeth (2). Abdomen fuscous or ochreous. Forewings formed nearly as in *copularis*, but slightly broader and less elongate; fuscous, sometimes dark fuscous in disc, in one ♂ ochreous-brown; a white or whitish dot edged with dark fuscous in disc towards base (in ♀ sometimes absent), a second at $\frac{1}{4}$, sometimes enlarged into an irregular spot or lengthened posteriorly into a streak, and an irregular longitudinal mark somewhat beyond middle; in ♂ some whitish suffusion or ring-marks towards dorsum anteriorly; a confluent irregular series of small dark whitish-ringed sometimes pale-centred marks crossing wing about $\frac{2}{3}$, more defined in ♂, sometimes preceded in disc by a partial second series of similar marks, sometimes connected with a whitish patch beneath middle of disc; a whitish ring-mark on costa before apex; a terminal series of small dark semicircular spots edged with whitish: cilia whitish or whitish-ochreous, barred with fuscous or dark fuscous. Hindwings fuscous, in one ♂ suffused with light ochreous; cilia as in forewings.

West Plains, Invercargill (Philpott); six specimens.

Micropterygidae.

Sabatinca Walk.

This generic name supersedes *Palaeomicra* Meyr., but I have formed a new genus, *Micropardalis*, to contain *doroxena* Meyr.

Sabatinca caustica n. sp.

♂. 9–10 mm. Head and thorax bronzy-orange-ochreous, thorax sometimes marked with whitish. Antennae ochreous, towards apex blackish. Abdomen dark purple-grey. Forewings ovate-lanceolate, costa moderately arched, apex pointed, termen extremely obliquely rounded; violet-coppery-ochreous, in one specimen largely suffused with whitish; in one specimen a spot of dark purple-fuscous suffusion on dorsum towards base, one in disc beyond middle, and some irregular marking towards termen, and in the whitish-suffused specimen the dark purple-fuscous suffusion forms a blotch along anterior portion of costa connected with a large oblique blotch in middle of disc, a streak along dorsum from base to $\frac{2}{3}$, a subterminal fascia enclosing a white spot on costa, and a mark along termen in middle, but in the other two specimens there are no markings: cilia golden-ochreous. Hindwings deep purple; cilia pale golden-ochreous.

Seaward Moss, Invercargill, in October (Philpott); four specimens. The amount of variation is remarkable, but all the specimens were taken together, and are undoubtedly the same species; the shape of forewings is characteristic, being more pointed than in any other species. The species may be placed between *zonodoxa* and *chrysargyra*.

Sabatinca incongruella Walk.

This name supersedes *chalcophanes* Meyr.

Sabatinca calliarcha n. sp.

♂. 12 mm. Head light bronzy-ochreous, hairs extremely long. Antennae pale ochreous ringed with dark fuscous. Thorax clothed

with long bronzy-ochreous hairs, beneath which is a white bent stripe on each side of back. Abdomen blackish, apex ochreous-whitish. Forewings elongate-ovate, costa moderately arched, apex obtuse, termen very obliquely rounded; yellow; dorsum suffused with ferruginous-brown, with a few black scales on edge; four golden-whitish streaks from costa between base and $\frac{2}{3}$ converging towards posterior half of dorsum, first edged posteriorly with ferruginous-brown mixed with indigo-black, hardly reaching dorsum, other three margined on both sides with ferruginous-brown streaks and on costa with black, second and fourth reaching dorsum, third reaching about half across wing; posterior area ferruginous-brownish somewhat mixed with pale yellowish, with an irregular black dot in disc at $\frac{3}{4}$, and four black dots on costa edged beneath with golden-whitish; a thick black streak lying along termen from near apex to tornus, edged with ochreous-yellowish and interrupted to form a long upper and short lower portion, upper portion including two golden-metallic terminal dots: cilia light ochreous-yellowish, with a violet-coppery basal line edged externally with grey. Hindwings deep purple, disc and veins blackish; cilia blackish-grey.

Bluecliff, Invercargill, in December (Philpott); one fine specimen. This is a beautiful and remarkably distinct species, showing some superficial approximation to *Micropardalis doroxena*, but structurally a true *Sabatinca* in all respects. I regard it, however, as the earliest form of the genus. I entertain no doubt that other forms of this primitive family remain to be discovered in New Zealand, and, as they are amongst the most important and interesting elements of the fauna, it is very desirable that collectors should make special efforts to find them. Probably the larvae feed on damp mosses, and Conifer forests are the most likely locality, especially in the early part of the season, perhaps before collectors usually take the field. The perfect insects fly in the sunshine, but in partially shaded places, and are sometimes extremely difficult to see.

Addendum.

Since writing the above, additional material has been submitted to me, which includes the two following species:—

Eucosma querula n. sp.

♂♀. 21–28 mm. Head, palpi, and thorax dark fuscous. Abdomen fuscous, not hairy. Forewings elongate-triangular, costa gently arched, in ♂ with very short and narrow basal fold, apex obtuse, termen rounded, rather oblique; purplish-bronzy-fuscous suffusedly mixed and strigulated with dark fuscous; costa obscurely pale-strigulated on posterior $\frac{2}{3}$; a whitish or ochreous-whitish dot in disc at $\frac{2}{3}$; two or three variable curved transverse series of small dark-fuscous spots or dots between this and termen: cilia fuscous, with darker line near base. Hindwings fuscous, posteriorly sometimes faintly darker-strigulated; in ♂ without special characters; cilia pale fuscous.

Christchurch and Wellington, in April (Philpott, Hudson); four specimens. I have also two ♀ from Queensland which I refer with little doubt to this species; I suppose it to be indigenous in Australia (and very likely in some of the Malayan islands), and to have been recently introduced into New Zealand. It belongs to a group of several Indian and Malayan species which are almost exactly alike in superficial appearance, but possess good

characters for discrimination in the secondary sexual structures of the ♂ —viz., the costal fold of forewings, the folding and tufting of the dorsal margin of hindwings, and the presence of hairy tufts on the abdomen.

Sabatinca quadrijuga n. sp.

♂. 13 mm. Head pale-greyish. Antennæ dark fuscous. Thorax purplish. Abdomen grey, lateral claspers and supraanal projection longer and narrower than in *caustica*. Forewings ovate-lanceolate, less acute than in *caustica*, stalk of 7 and 8 extremely short; deep purple, irregularly mixed with coppery-golden, darker and bluish on costa; four subquadrate ochreous-whitish spots on costa between base and ¾, larger anteriorly, and a dot towards apex: cilia grey-whitish, with several dark-grey bars. Hindwings violet-grey, darker towards apex; cilia grey-whitish, on costa barred with grey suffusion.

Invercargill (Philpott); one specimen received through the kindness of Mr. Hudson.

Art. X.—*Notes on some Dragon-flies from the Kermadec Islands.*

By R. J. Tillyard, M.A., F.E.S.

[*Read before the Wellington Philosophical Society, 9th August, 1911.*]

In a small collection forwarded to me by Mr. A. Hamilton, of Wellington, New Zealand, five species are represented, four being species of wide distribution in the Australasian region, and the fifth (represented by a solitary female) probably a local race of a widely distributed oceanic genus of which the species and races have not yet been correctly worked out. They are the following.

Fam. LIBELLULIDAE.

Subfam. Libellulinae.

1. **Tramea** sp., 1 ♀ (label No. 2).

Somewhat immature, and of pale coloration. The dark patch at the base of the hindwings is exceedingly small, and does not spread downwards into the anal areas of the wing. The male of the insect should be obtained, as from the form of the ♂ appendages and genitalia the species could be determined with certainty. I am of opinion that this will prove to be a local race of a widely distributed oceanic species. The genus is highly migratory, and one species is rapidly travelling down the east coast of Australia, and getting a strong hold there.

Subfam. Corduliinae.

2. **Hemicordulia australiae** Rambur (label No. 3).

2 ♀, 2 ♂. In good condition, a dark and handsome form, practically identical in size and colouring with the specimens found in the Sydney district. This beautiful species, recognizable by the brilliant metallic-green

frontal patch on the head, and the sharp spine on the underside of the male appendages, has never before been recorded outside Australia. It ranges from Victoria, through New South Wales, to northern Queensland, but does not occur west of the main mountain-ranges. Its capture in the Kermadec Islands is therefore of considerable interest. The genus *Hemicordulia* is post-Miocene, so that the occurrence of this species may be taken as evidence of late land connection between Australia and the Kermadecs. The species is non-migratory, and does not occur in Tasmania, though exceedingly common on the northern shores of Bass Strait. The inference, therefore, is that the Kermadecs may have been united in some way, possibly *via* New Caledonia and Queensland, to Australia since the time (? Miocene) when Tasmania became separated. We should also expect, possibly, to find this species on Lord Howe and Norfolk Islands, whose Odonate fauna are still unknown.

Fam. AESCHNIDAE.

Subfam. AESCHNINAE.

3. Hemianax papuensis Burmeister (label No. 1, ♂).

1 ♀. Immature, but a fine specimen (appendages broken). Common all over New Guinea and Australia, except Tasmania, where it is absent. A strong flier, but not migratory. This reinforces the evidence of No. 2, *Hemianax* also being a Miocene or post-Miocene genus.

4. Aeschna brevistyla Rambur, 2 ♂ (label No. 1, ♀).

One specimen immature, one mature. This insect is found all over Australia, except in the most northern parts. It also occurs in Tasmania. In New Zealand a somewhat smaller and darker form occurs, which, though clearly conspecific with the Australian, may be distinguished at once from it by its abdomen being exceedingly pinched at the third segment, and its membranule very dark, with only a little white at the base. The Kermadec specimens are identical with the New Zealand form.

Fam. AGRIONIDAE.

Subfam. AGRIONINAE.

5. Ischnura aurora Brauer (= *I. delicata* Selys), (label No. 4).

5 ♂, 6 ♀. A very beautiful species, of wide distribution, ranging from the islands north of Australia, through Australia, to Tasmania. In Western Australia a dimorphic female, coloured like the male, occurs. The male has a bright-red abdomen shading to black, with a blue tip; the ordinary female is dull-blackish. These Kermadec specimens are practically identical with any series of this insect taken round Sydney.

In conclusion, therefore, this small collection shows the Kermadec *Odonata* to have a strong Australian element (three species out of five), a New Zealand element (one species), and an oceanic element (one species)

Art. XI.—*Miscellaneous Notes on some New Zealand* Crustacea.

By Charles Chilton, M.A., M.B., D.Sc., F.L.S., Professor of Biology, Canterbury College, University of New Zealand.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1911.*]

This short paper contains a few miscellaneous notes that have been made during recent years on some New Zealand *Crustacea*. Though there are many other questions that require to be settled, and several groups that need thorough revision, it has been thought worth while publishing these few notes as they stand, though they are necessarily somewhat disconnected, and deal with scattered members of the *Crustacea*.

Order Decapoda.

Hymenosoma lacustris Chilton.

Elamena (?) *lacustris* Chilton, Trans. N.Z. Inst., vol. 14, p. 172, pl. 8, 1882. *Hymenosoma lacustris* Chilton, Trans. N.Z. Inst., vol. 15, p. 69, 1883; Fulton and Grant, Proc. Roy. Soc. Victoria, vol. 15, p. 59, pl. 8, 1902; Chilton, P.Z.S. for 1906, p. 703, 1906.

This small fresh-water crab was originally described from Lake Takapuna (or "Pupuke"), near Auckland, which is quite near the sea-coast, and for a long time this was the only locality from which it was known, and it was a little uncertain whether it was a genuine fresh-water form or a relict species that had only comparatively recently developed in Lake Takapuna. In 1902, however, Messrs. Fulton and Grant recorded the species from Lake Colac, in Victoria, and about the same time I received several specimens from Norfolk Island. Specimens from all these localities were examined by Messrs. Fulton and Grant, and, although there are a few slight differences, these were found to be not constant, and they decided to consider all the forms as belonging to the one species.

In 1903 two specimens of the crab were found by Messrs. Hodgkin and Lucas in Lake Waikare, in Auckland, which is a considerable distance from the coast; and in the early part of this year (1911) a few specimens undoubtedly belonging to the same species were sent to me by Mr. Cheeseman from the Waipa River.

It seems evident from the above facts that the species is a widely distributed inhabitant of fresh waters, and its occurrence in the fresh waters of New Zealand, Norfolk Island, and Victoria presents a problem of some interest in connection with the geographical distribution of the *Crustacea*. In connection with this point, it is, however, worth while stating that the fresh-water shrimp in Norfolk Island and Victoria is *Xiphocaris compressa* De Haan, and is quite different from the species, *X. curvirostris* Heller, which is found in nearly all the fresh-water streams of New Zealand, and occurs also in the Chatham Islands.

Munida gracilis Henderson.

Munida gracilis Henderson, Ann. Mag. Nat. Hist., ser. 5, vol. 16, p. 411, 1885; and "Challenger" Reports, vol. 27, p. 143, pl. 3, fig. 6, 1888.

Three imperfect specimens found in the stomach of a fish, Kaikoura. These agree very closely with Henderson's descriptions, but they are of much larger size. One of them, a female bearing eggs, has the following dimensions: Length of body, 54 mm.; breadth of carapace, 16 mm.; length of carapace, 19 mm.; length of rostrum, 13 mm.; length of chelipeds, 70 mm.

Two specimens were taken by the "Challenger" at Station 166, west of New Zealand, at a depth of 275 fathoms, but so far as I am aware the species has not been seen since until the specimens now described were handed over to me by Mr. Waite, Curator of the Canterbury Museum.

Cryptodromia lateralis Gray.

Cryptodromia lateralis Miers, Cat. N.Z. Crust., p. 57, 1876; G. M. Thomson, Trans. N.Z. Inst., vol. 31, p. 170, pl. 20, figs. 1 and 2, 1898; Hutton, N.Z. Journ. Sci., vol. 1, p. 264, 1882.

This species was recorded from New Zealand by Heller, and specimens in the British Museum collections were referred to it with some doubt by Miers when he was preparing the "Catalogue of the New Zealand Crustacea." In 1882 Hutton included it in a list of species which had been recorded from New Zealand, and might really belong to New Zealand, although at the time he wrote they were not represented in any local collections known to him. This was still the case when Thomson prepared his "Revision of the Crustacea Anomura," in 1897. Two or three years ago, however, I received from Captain Bollons a specimen, dredged in Hauraki Gulf at a depth of 22 fathoms, that undoubtedly belongs to this species, so that, like some of the other species first recorded from New Zealand by Heller, and since considered doubtful, it is found in New Zealand seas, though, apparently, only occasionally. The species is also known from Australia and Tasmania.

Order Amphipoda.

Leucothoe traillii G. M. Thomson.

Leucothoe traillii G. M. Thomson, Trans. N.Z. Inst., vol. 14, p. 234, pl. 18, fig. 1 *a–d*, 1882; Stebbing, Das Tierreich Amphip., p. 164, 1906. *L. tridens*, Stebbing, Rep. Voy. "Challenger," vol. 29, p. 777, pl. 47, 1888; Chilton, Trans. N.Z. Inst., vol. 38, p. 268, 1905; Stebbing, Das Tierreich Amphip., p. 166, 1906.

I have no doubt these two species should be combined. I had identified specimens from Hauraki Gulf as *L. tridens* Stebbing, but I find that they are the same as a Lyttelton specimen that I had years ago referred to *L. traillii* G. M. Thomson, and I find from comparison of these with named specimens of this species since received from Mr. Thomson that no difference can be detected between them. Mr. Thomson describes the dactyl of the first gnathopod as being "finely serrated on its inner margin," but in all my specimens it appears quite smooth. In Mr. Thomson's mounted specimen the dactyl lies close up against the propod,

and its inner margin cannot be clearly seen, but it appears smooth there also. In his original description Stebbing describes the telson as having "the minute apex microscopically tridentate," and figures it as distinctly tridentate; in the "Das Tierreich" description he simply says, "apex a little obtuse," which perhaps more accurately describes the appearance of the telson in those specimens that I have examined.

Hab.—Hauraki Gulf (25 fathoms), Paterson Inlet (10 fathoms). Taken also in New Zealand seas by the "Challenger" (2,000 fathoms).

Pontogeneia danai (G. M. Thomson).

Atylus dania, *A. danai* G. M. Thomson, Trans. N.Z. Inst., vol. 11, pp. 238, 248, pl. 10F, fig. 1, 1879. *Pontogeneia danai* Stebbing, Das Tierreich Amphip., p. 360, 1906. *Atylus lippus* Haswell, Proc. Linn. Soc. N.S.W., vol. 4, p. 328, pl. 20, fig. 1, 1880, and Cat. Aust. Crust., p. 243, 1882; Chilton, Proc. Linn. Soc. N.S.W., vol. 9, p. 1037, 1885. *Eusiroides lippus* Stebbing, Das Tierreich Amphip., p. 346, 1906; Stebbing, Results "Thetis" Exped., Memoir Aust. Mus., vol. 4, p. 639, 1910.

Lyttelton, Akaroa, Dunedin (G. M. Thomson), Bluff (L. Cockayne), Stewart Island (H. B. Kirk). Also Port Jackson, New South Wales, and Portland, Victoria.

Very common in rock-pools; colour very variable.

Closely allied to *P. antarctica* Chevreux, from which it differs in having every 4th (or 5th) segment of flagellum of antennules dilated and the dilatation more prominent.

Atylus lippus Haswell is put down by Stebbing as an obscure species of *Eusiroides*. I have, however, several specimens from Sydney Harbour and other places in Australia which seem undoubtedly to belong to Haswell's species, and they certainly should be placed under *Pontogeneia*, and a comparison of them with New Zealand specimens shows that they are the same as *P. danai* G. M. Thomson, a species described a year earlier.

Paraleptamphopus subterraneus (Chilton).

Paraleptamphopus subterraneus (Chilton), Trans. N.Z. Inst., vol. 41, p. 54 (with synonomy).

In the paper quoted above I gave the localities from which the species had been found up to that time. Shortly afterwards, on the 24th December, 1908, I took it among moss, &c., in a small mountain-stream at Duck Cove, Dusky Sound. The specimens were perhaps slightly yellower than those found underground, but showed no sign of eyes, and in all other respects seem quite the same as those first found in the underground waters of the Canterbury Plains.

In January, 1911, Mr. W. F. Howlett sent me specimens from Eketahuna, which had been obtained from a well in the same way as those originally got from the Canterbury Plains. The only previous record from the North Island had been one specimen obtained in Lake Taupo, at a depth of 700 ft., by Messrs. Hodgkin and Lucas.

It is evident that this species is even now widely distributed throughout New Zealand, usually inhabiting underground waters, but occasionally found also in surface streams.

Elasmopus viridis (Haswell).

Moera viridis Haswell, Proc. Linn. Soc. N.S.W., vol. 4, p. 333, pl. 21, fig 1, 1879. *M. incerta* Chilton, Trans. N.Z. Inst., vol. 15, p. 83, pl. 3, fig. 3, 1883. *Elasmopus viridis* Stebbing, Das Tierreich Amphip., p. 445, 1906.

Several specimens from Island Bay, Wellington (Farquhar coll.), were in Mr. G. M. Thomson's collection. The species is known from Australia also.

When I described this species under the name *Moera incerta* I had seen only specimens in which the second gnathopod had the palm straight —*i.e.*, the females. Since then I have seen a few in which the palm has a slight central cavity, as described by Haswell and Stebbing, though the cavity is by no means so deep as that shown in Haswell's figures; I think, therefore, that Stebbing is right in uniting the two species. These specimens, are, I presume, males, and it is worthy of note that in this species the females have the second gnathopods approximately as large as those in the males, and, with the exception of the palm, of the same general shape.

Phronima novae-zealandiae Powell.

Phronima novae-zealandiae Hutton, Index Faunae N.Z., p. 256, 1904.

This is a common pelagic form often washed up on the sandy beaches of New Zealand. In June, 1911, two specimens were found at Sumner, where Powell's type specimens were captured, and were sent on to me by Professor Park, of Dunedin. In March, Mr. C. Barham Morris, of Oamaru, sent me a mounted slide of a small *Phronima* taken at Tomahawk Beach, Dunedin. This specimen appeared to be identical with the one referred to *P. pacifica* Streets by Stebbing in the "Challenger" Reports (p. 1350). As *P. pacifica* had not been previously recorded from New Zealand, I wrote to Mr. Morris asking if he had further specimens, and in reply was informed that the small specimens were taken along with ordinary large specimens which he considered to be *P. novae-zealandiae*.

I find from the examination of one of the large specimens kindly forwarded by him that this identification is quite correct, and it appears almost certain, therefore, that the small specimens taken at the same time are simply immature forms of *P. novae-zealandiae*. Most of them measure about 4 mm. in length. The "Challenger" specimen, which was taken in the Atlantic Ocean, off Sierra Leone, was "$\frac{3}{10}$ in." in length, and was therefore probably an immature form also.

P. pacifica was originally described by Streets from the North Pacific Ocean, and was said to be distinguished from *P. sedentaria* by the broadly quadrate form of the carpus of the third pair of thoracic feet and by having the carpus of the second gnathopods less produced anteriorly. It was also pointed out that there was a striking resemblance of the smaller specimens of *P. pacifica* and the corresponding parts of *P. atlantica*, which is said to be the female of *P. sedentaria*. It appears, then, that there is some suspicion that *P. pacifica* is not a distinct species, but perhaps an immature stage.

Unfortunately, I am unable to consult all the literature necessary on this point, but the forms I have seen undoubtedly seem to be the young of *P. novae-zealandiae*, and if not identical with *P. pacifica* are extremely

close to it. This seems to make it more probable that *P. novae-zealandiae* is identical with *P. sedentaria*, as was suggested by Stebbing in the "Challenger" Report.

Order Isopoda.

Iais pubescens (Dana) var. longistylis var. nov.

This variety differs from the typical form of the species in the longer uropods, which are fully half as long as the pleon; the peduncle is shorter than the rami, and may be slightly dilated at the distal end; the outer ramus is almost or quite as long as the inner, but slightly more slender, and has long setae, usually at the end only; the inner ramus has long setae both at the end and at a point some distance from the end.

Hab.—On *Sphaeroma quoyana*, Marlborough Sounds and Hawke's Bay. Also on specimens of the same species from Sydney Harbour.

I have had specimens of this variety for several years. The difference between it and the typical form of the species is sometimes so distinct that I have at times almost been inclined to give it a different specific name, especially as it appears to be always associated with a different species of *Sphaeroma*. I find, however, that *Iais pubescens* found on *Sphaeroma gigas* shows considerable variation in the length of the uropods; I have one specimen from Lyttelton which has them much longer than usual, and approaching the condition found in the variety now described, while others from Port Chalmers have the uropods much shorter, with the outer ramus very small and only about half as long as the inner one. I can, moreover, find no constant points of difference except in the uropoda, and therefore prefer to look upon the form found on *S. quoyana* as merely a variety of the species.

Haliacris neozelanica (Chilton).

Munna neozelanica Chilton, Ann. & Mag. Nat. Hist., ser. 6, vol. 9, p. 1, pl. 1 and 2, 1892. *Haliacris neozelanica* Chilton, Subant. Islands N.Z., p. 650, 1909.

A number of specimens that appear to belong to this species were taken at Waikawa Bay, in Queen Charlotte Sound, near Picton, in July, 1910. They were found in considerable numbers creeping on the under-surface of stones in a fresh-water stream at a point a little above high-water mark, the water at that place being at the time quite fresh, though it would be probably more or less influenced by high tides. The animals were all very small, and I have not been able to find one having the characteristic development of the first pair of legs of the adult male; but, so far as can be seen, the specimens are not structurally different from those gathered at the type locality in Port Chalmers, though they have the body rather darker in colour.

One similar specimen was also taken at Portage, on Kenepuru Sound, also at the mouth of a small stream, and in both cases specimens of *Phreatogammarus propinquus* were taken at the same time and place. Many years ago I collected one or two specimens in a similar situation at Waitati Estuary, Otago, but they were so minute that an exact identification at the time was impossible.

Structurally these fresh-water or brackish-water specimens do not seem to differ from the typically marine form, but there seems not much

doubt that they do differ considerably in habit, and perhaps should be looked upon as a special variety. All the specimens found were quite small, not more than 2 mm. in length, and it is, of course, possible that only the young stage is passed through in the stream, and that as the animals become older they take to the sea.

Jaeropsis curvicornis (Nicolet).

Jaera curvicornis Nicolet in Gay's Hist. fis. y pol. de Chile, vol. 3, p. 263, pl. 3, fig. 10, 1849. *Jaeropsis neo-zelanica* Chilton, Trans. N.Z. Inst., vol. 24, p. 267, 1892. *J. curvicornis* H. Richardson, Trans. Connect. Acad. Sci., vol. 11, p. 298, 1902; Stebbing, Ceylon Pearl Fisheries Report, pt. 4, p. 51, pl. 11 (*c*). 1905. *J. patagoniensis* H. Richardson, Proc. U.S. Nat. Mus., vol. 36, p. 421 (with figure), 1909.

I have specimens of this species from Akaroa, Taylor's Mistake, and Lyall Bay. The colour seems somewhat variable, the dorsal surface being a light brown and legs whitish; in one specimen, however, the brown colour was present only on the posterior part of the head and the first four segments of the paraeon, the remainder of the dorsal surface being whitish. The Akaroa specimen, which I described in 1892 under the name *Jaeropsis neo-zelanica*, is a very small one, only about 2 mm. in length; one of the specimens from Taylor's Mistake is considerably larger, being 5 mm. in length, and comparison of this, which I have no doubt belongs to the same species as the Akaroa and other specimens, enables me to give some points in which the larger and presumably adult specimen differs from the small immature ones. In the larger specimen the flagellum of the antennae is considerably longer than in the other specimens, and consists of about twelve joints, the first one being much the largest, as long as the remainder together, and being broadly expanded. In this specimen, too, the sides of the pleon are smooth, except for a small tooth about a third the length from the posterior end. In small specimens the sides of the pleon are somewhat serrated, the last serration, which corresponds with the one still present in the older specimen, being slightly the most prominent.

All the species of this genus appear very closely similar, and from what has been said above it seems probable that some of them have been established on small and possibly immature specimens. I think Mr. Stebbing is right in uniting *J. neo-zelanica* with *J. curvicornis* (Nicolet), and the specimens which he describes from the Gulf of Manaar certainly seem to be close enough to be placed under this species. I have no doubt also that the specimens more recently described by Miss H. Richardson under the name *J. patagoniensis* also belong here, the pleon agreeing closely with that of my larger specimen; the other points she mentions, as regards colour, &c., are hardly of specific importance; the lobe at the front of the head is described and figured by her as having a small point in the centre, while in my specimens it is rounded in front. Nicolet draws his specimens with this lobe slightly concave in front, and, in any case, the difference appears to be very trifling. *J. marionis* Miers, taken by the "Challenger" off Marion Island, seems to be pretty closely allied, but, as represented by Miers, has the joints of the antennae much less expanded, and the uropoda are perhaps rather different in structure.

Sphaeroma quoyana Milne-Edwards.

Sphaeroma quoyana Milne-Edwards, Hist. Nat. des Crust., vol. III, p. 206, 1840; Heller, Reise der Novara, Crust. p. 137, 1868; Haswell, Cat. Aust. Crust., p. 287, 1882; Hedley, Rep. Aust. Assoc., vol. 8, p. 239, pl. 10, fig. 1, 1901. *S. verrucauda* White, List Crust. Brit. Mus., p. 102 (*sine descr.*), 1847; Dana, U.S. Explor. Exped., vol. 14, Crust., pt. 2, p. 779, pl. 52, fig. 6, 1853; Miers, Cat. N.Z. Crust., p. 111, 1876; Haswell, Cat. Aust. Crust., p. 288, 1882; Hutton, Index Faunae N.Z., p. 263, 1904; Stebbing, Spolia Zeylanica, vol. 11, pt. 5, p. 21, 1904; Hansen, Q. J. Micro. Soc., vol. 49, pt. 1, p. 116, 1905; Hedley, Rep. Aust. Assoc., vol. 8, p. 239, 1901.

Sphaeroma quoyana was described by Milne-Edwards in 1840 from Australian specimens, but nothing appears to have been recorded by him about its boring habits. Haswell had not seen the species when preparing the "Catalogue of the Australian Crustacea."

In 1853 Dana described a species under the name of *S. verrucauda*, from the Bay of Islands, New Zealand, his specimens having been found "in rotten wood in cavities bored by *Teredo*." Miers, in his "Catalogue of the New Zealand Crustacea," in 1876, records the species from "Auckland, Hobson's Bay," and notes that these specimens inhabited "similar cavities in a piece of sandstone." He also mentioned that specimens from Port Jackson, Australia, were in the collections of the British Museum, but that the New Zealand specimens were much more hairy than those from Australia. Many years ago Mr. J. Macmahon sent me numerous specimens that I identified as *S. verrucauda*, which he found boring into soft sandstone on the shores of Kenepuru Sound, and in July, 1910, I found similar specimens in the neighbouring Queen Charlotte Sound, and was able to see for myself beyond doubt that the holes in the sandstone were bored by the *Sphaeroma* and not by a *Teredo;* the holes vary in size from 2 mm. to 7 mm. in diameter, and were occupied by *Sphaeromae* of corresponding sizes, and there was no trace of any *Teredo* in the sandstone.

In 1901 Hedley, in a paper on the "Marine Wood-borers of Australasia," mentions both *S. verrucauda* and *S. quoyana*, the latter having been found boring in wood in Sydney Harbour, and mentions that it hardly differs from *S. verrucauda.* In 1903 I received from Mr. T. Whitelegge specimens of *S. quoyana* from Sydney Harbour, and in forwarding them he said, "*S. quoyana* is identical with specimens from Mr. Thomson's collection labelled '*S. verrucauda.*'" These specimens were some of those that had been handed on by me to Mr. Thomson.

I have now been able to compare specimens from different parts of New Zealand, and also others, labelled "*S. quoyana*," from Victoria and Tasmania, and I quite agree with Mr. Whitelegge that the two species should be united. The species belongs to the same section of *Sphaeroma* as *S. terebrans* Spence Bate and the other species found boring into wood in various parts of the world, and the fact that *S. quoyana* is undoubtedly able to bore into sandstone seems worthy of definite record.

Iais pubescens var. *longistylis* (see above) seems to be regularly associated with *S. quoyana* as a commensal or semiparasite just as the typical form of *I. pubescens* is with *Sphaeroma gigas.*

Exosphaeroma chilensis (Dana).

Sphaeroma chilensis Dana, U.S. Expl. Exped., Crust., p. 177, pl. 52, fig. 3 *a-c*, 1853. *Exosphaeroma chilensis* Chilton, Rec. Cant. Mus., vol. 1, p. 310, 1911.

Three specimens of this species were obtained at the Chatham Islands during the trawling cruise of the "Nora Niven," and are described in my report of the results of that cruise. I had previously had specimens from Lyttelton and Auckland, the latter collected by Mr. Suter.

The occurrence of the species in New Zealand is noteworthy as another addition to the marine species common to New Zealand and to South America.

Livoneca raynaudii Milne-Edwards.

Livoneca raynaudii M.-Edw., Hist. Nat. Crust., vol. 3, 1840, p. 262; Thielemann, Abhand. K. Bayer. Akad. d. Wissensch., 2, Suppl. Bd., 3 Abhand., p. 42, 1910; Chilton, Rec. Cant. Mus., vol. 1, p. 309, 1911.

I have discussed the synonomy of this species, which has so long been known in New Zealand under the name of *L. novae-zealandiae*, in the paper quoted above. The species is widely distributed in southern seas, and Thielemann records it also from Yokohama, adding that it is closely allied to *L. californica* Sch. & M., from the coast of California. *L. epimerias* Richardson, from Japan, also seems to be very closely allied, but, according to Miss Richardson, differs in the shape of the head and the epimera.

Art. XII.—*Report on Sundry Invertebrates from the Kermadec Islands.*

By Professor Benham, D.Sc., F.R.S., Otago University.

[*Read before the Otago Institute, 3rd October, 1911.*]

Mr. Oliver was good enough to hand to me (for the purpose of identification, or description if need be) representatives of various classes of non-vertebrata collected by him during his sojourn on Sunday Island. Unfortunately, my time has not allowed me to touch the *Oligochaeta*, the *Polychaeta*, *Nemertines*, or parasitic worms. In this brief report there are one or two points upon which I have to express uncertainty, owing to the lack of necessary literature; but it seems desirable to present this list, as I do not see any prospect of being in a better position in the immediate future to deal more fully with them.

Class Hydrozoa.

Order Siphonophora.

Physalia utriculus Eschscholtz.

Lesson, Voy. de "Coquille," vol. 2, pt. 2, chap. 15, p. 39; Zoophytes pl. 5, fig. 2. Haeckel, "Challenger" Reports, 28, p. 351.

Cast ashore on Denham Bay, Sunday Island. Widely distributed in the Pacific.

Velella cyanea Lesson.

Lesson, Voy. de "Coquille," vol. 2, pt. 2, chap. 15, p. 54; Zoophytes, pl. 6, figs. 3, 4. Haeckel, "Challenger" Reports, 28, p. 83.

This common Pacific species was cast ashore on Denham Bay.

Class Scyphozoa.

? Atolla sp.

A single somewhat torn and distorted specimen, measuring 30 mm. in diameter, with a height of 15 mm. in the centre of the umbrella, was found on the shore of Sunday Island. It was so much injured that I am not quite sure even of the genus; but it agrees in so many features with *Atolla* that I have but little hesitation in placing it here. I will not, however, attempt to give a specific name to it.

Class Holothuroidea.

Actinopyga (Muelleria) parvula Selenka.

M. flavo-castanea Theel: Selenka, Zeit. Wiss. Zool., 17, 1867. "Challenger" Reports, Holothuroidea, pt. 2, p. 198, 1886.

Fifteen specimens were sent to me. Oliver notes that the "colour is dark brown to nearly black: common at Coral Bay, under stones near low-water mark; not seen elsewhere." In alcohol it is chocolate-brown with a purplish hue. The majority are uniformly coloured, darker dorsally and only slightly paler ventrally; but in four individuals there is an abrupt transverse line separating the dark anterior region from a posterior paler region. In one specimen the change occurs at about $\frac{3}{5}$ of its length from the anterior end, in two others at $\frac{3}{4}$, and in one at $\frac{1}{7}$ of the length. From the condition of the ventral ambulacra it appears that this hinder end has been regenerated, for here the podia are in distinct narrow lines, whereas in the normal darker part of the body these organs spread out into the interambulacra, where there are about 15 in a transverse line, instead of only 2 to each ambulacrum. There is, too, a transition observable as the ambulacra are traced forwards, indicating a gradual resumption of the adult condition.

Distribution.—Bedford, in his report on the Funafuti Holothurians, speaks of this species as "the most widely distributed circumtropical species of the genus."

Chirodota rigida Semper.

Semper, Reisen im Archipel der Philippinen, Holothurien, p. 18, pl. 3, fig. 3; pl. 5, figs. 3, 13, 1868. Lyman Clark, "The Apodous Holothurians," p. 117, 1907.

The wheels differ from those figured, in that there is a distinct constriction of the radii at their junction with the rim; but, as my specimens agree in the general characters of the species, I have little doubt that this is the correct determination. Oliver states that the "general colour is reddish-purple; it occurs in sand and mud under stones in rock-pools and at low-water mark. It is not common."

Loc.—Meyer Island.

Distribution.—Clark says it is "apparently well distributed through the entire East Indian region."

Class Sipunculoidea.

Sipunculus nudus Linnaeus.

This Mediterranean species is widely distributed; it has been recorded from Singapore, Japan, and elsewhere.

Loc.—Sunday Island.

Collected by Mr. R. S. Bell.

Physcosoma scolops. Selenka and Man.

Phascolosoma annulata Hutton, Trans. N.Z. Inst., 12, p. 278, 1880. *Phymosoma scolops* Selenka and Man, "Die Sipunculiden," p. 75, 1884. *Physcosoma annulatum* Benham, Trans. N.Z. Inst., 36, p. 173, 1904.

When I described the Sipunculids of New Zealand (Trans. N.Z. Inst., vols. 36, 37) I had not the opportunity of consulting Selenka's monograph, which was only purchased by the Otago Institute at a later date. I find now that our common Sipunculid, which Hutton described in 1879, is identical with Selenka's *P. scolops*, a very widely distributed species, which was described five years later. Hutton's brief diagnosis, depending only on externals, is insufficient for identification, and so must give way to Selenka's specific name.

I note that, although Fischer (Die Gephyrea, Abhandl. aus dem Gebiete Naturwiss., 13, p. 10, 1895) regards *P. scolops* as a variety of the Mediterranean *P. granulatum*, Shipley still retains it as a distinct species (Willey, Zool. Results Rep. on the Sipunculoidea, p. 156, 1899; and Rep. on the Gephyrea, Pearl Oyster Fishery, Ceylon, p. 174, 1903).

It is evidently very common on the Kermadec Islands, for I have more than fifty I collected on various parts of Sunday Island and on Meyer Island in the ordinary positions—that is, under stones in rock-pools, in amongst coralline algae, &c.

The distribution is very wide.

Aspidosiphon truncatus Keferstein.

Selenka and Man, "Die Sipunculiden," p. 118, pl. 13, 1884.

Of this identification I do not feel quite certain, for the convolutions of the intestine are fewer, and the longitudinal muscle bands rather more numerous; but as our specimens agree in so many features with those of Keferstein's species, and do not agree with any other description to which I have access, I place it here. The differences are so slight that I do not feel competent to differentiate a new species.

Loc.—Sunday Island, in coralline algae. Six specimens.

Distribution.—Mauritius, Panama, Japan (Ikeda, Journ. Coll. Sci., 20).

Class Chaetognatha.

Sagitta fowleri nom. nov.

Fowler, "On Plankton Chaetognatha of the Bay of Islands, New Zealand," Ann. Mag. Nat. Hist. (8), 1, p. 240, 1908.

I received seven specimens of a rather large Chaetognath which had been cast ashore, and were somewhat injured, and had unfortunately been placed in a tube rather too small for them, so that they are not only damaged by the sand, but also folded and crumpled. At first I failed to notice the anterior lateral fin, and took it for a species of *Krohnia;* but the formula given by Dr. G. H. Fowler for an unnamed species from the Bay of Islands

agrees so precisely with the Kermadec forms, and in some respects is so exceptional, that I carefully went through all the specimens again. In only one individual could I detect the anterior fin, and this quite plainly, although it was folded against the body. In its extent it does not agree with Fowler's figure, though he places a (?) against his statement in the text. But owing to the damage done to the posterior fin, and owing to the tenuity of this anterior fin, I should not presume to doubt Fowler's statement that this fin extends forwards as far as the level of the ventral ganglion, though, so far as my specimen shows it, the fin is of much less extent.

Fowler refrained from naming his two immature and somewhat damaged specimens, and did not even place it in a genus, though he states that certain of its characters "suggest *hexaptera*," at the same time pointing out certain differences from that species. As the only genus with two lateral fins is *Sagitta*, there is little doubt that he intended to compare it with *S. hexaptera*, and I take the opportunity of naming it after him.

My specimens vary from 23–35 mm. in total length, with a diameter of 2·5–3 mm. Owing to flaccidity of the body, it flattens easily, and has, as I have said, been crumpled.

The head is distinctly constricted from the body; the curved hooks, or "jaws," are 8 or 9 on each side; in one case 8 on one side and 9 on the other. They have no distinct separate tip, but the whole hook is gently curved and without any serrations.

The frontal spines, or "anterior teeth," are on 3 each side, though in one case 4 on one side and 3 on the other.

The marginal spines, or "hinder series of teeth," form a row of 3 short conical spines on the sloping anterior margin of the head.

The tail fin is in all my specimens slightly notched; the posterior lateral fin commences rather in front of the middle of the tail, and is widest just behind the anus. So far as the imperfect condition allows one to judge, it has $\frac{1}{3}$ of its length behind and $\frac{2}{3}$ in front of the anus.

The anterior fin is only 3 mm. in length; it seems well defined, and I failed to see any evidence of its continuation forwards; its anterior margin is 10 mm. from the tip of the head (the ventral ganglion being about 6 mm.); its posterior limit is 5 mm. in front of the anus—that is, close to the posterior fin.

The formula used by Fowler is—

Total Length.	Tail, as Percentage of Total Length.	Number of Jaws.	Number of Anterior Teeth.	Number of Posterior Teeth.
35	20	8	..	..
27	20	9	3	3
25	20·3	8–9	3–4	3

Loc.—Sunday Island.
Distribution.—Bay of Islands.

Class Enteropneusta.

Ptychodera flava Eschscholtz.

Willey, Q. J. Mic. Sci., 40, p. 165. Punnett, Enteropneusta, Fauna Maldive and Laccadive Archip., vol. 2, pt. 2.

A single lacerated broken individual, found "under stones" at Coral Bay, Sunday Island, July, 1908.

Distribution.—Indian Ocean.

Art. XIII.—*Earthquake-origins in the South-west Pacific in 1910.*

By George Hogben, M.A., F.G.S.

[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

The most interesting problems in connection with seismology at the present time are those relating to the paths of earthquake-waves through the earth. The paths of the so-called long waves, which show the maximum amplitude, lie, it is generally agreed, along arcs approximately parallel to the earth's surface, at no great depth below the surface. Their mean velocity of propagation is in almost all cases very near to 3·3 kilometres per second, or 200 kilometres (or 125 miles) per minute. The velocity of the preliminary tremors is much higher—often four times as great, or even more. These waves, being the first to be recorded, must travel by the brachistochronic path from the origin to the places of observation, and, whether this path be approximately rectilinear or not, the high speed of the waves shows that they must be transmitted through a medium or media of much greater elasticity than that possessed by the surface rocks. The determination of the actual path of these preliminary tremors is therefore the point upon which attention is being just now especially directed. The problem is mainly a geometrical problem, and obviously the first step is the determination of the positions of the epicentra of the earthquakes discussed. These epicentra are likely to be most correctly ascertained when the data used are those from observatories so near the origin that it may be reasonably presumed (a presumption to be tested by the agreement of the results) that the medium through which the waves travel is homogeneous, or nearly so, and yet not so near the origin that the ordinary errors of observation can substantially affect the results. If the paths of the preliminary tremors can be ascertained in such a way that we can formulate a general law, then we shall be able to draw, with a reasonable degree of certainty, inferences as to the constitution of the earth's interior —as to the density, elasticity, and thickness of the successive shells of which the earth is made up.

It therefore becomes the duty of the seismological observers in any region of the world to ascertain as nearly as may be the positions of the origins or of the epicentra of the principal earthquakes occurring in that region. Accordingly I have devoted myself during the last twenty years to the determination of earthquake-origins within the New Zealand region, and incidentally, at the request of the Seismological Committee of the Australasian Association, to finding the origins of some other Australasian earthquakes. It will be of more service to the solution of the problems in hand, however, if this work is extended to a wider region, and accordingly the results of systematic inquiry into the earthquake-origins of the whole south-west Pacific are now placed before you. Those in the present paper relate to the year 1910.

The records used are those received from the Milne seismograph stations, which are published twice a year by the British Association Seismological Committee, edited by Dr. John Milne, F.R.S.; also records received from the Directors of the observatories at Apia, Batavia, Manila, and Riverview, Sydney (the instruments at all the last-named observatories are of the Wiechert type). For these I am indebted to the courtesy of the respective Governments of Germany, Holland, and the United States, and to the kind offices of the Rev. Father Pigot, Director of the Riverview Observatory.

The waves used for determining the origins are the preliminary tremors and the long waves; the methods for the most part trial methods, such as the differential method and that based upon the interval between the arrival of the P_1 waves and those of maximum amplitude.

The results for eleven earthquakes in which the data are sufficient to determine the epicentra are given below. Those called "approximate" are epicentra probably correct within the limits of error of the observations; those called "probable" are epicentra for which there are residual errors somewhat in excess of the limits of errors of observation.

(It should be noted that the method of least squares cannot properly be used unless the physical conditions are approximately the same. For instance, we cannot use it in reference to equations based upon observations from stations varying greatly in their distance from the origin; it should be applied only to deductions from observations of waves passing along the same paths, or, assuming the symmetrical distribution of the various strata of the earth, passing along paths of nearly the same length.)

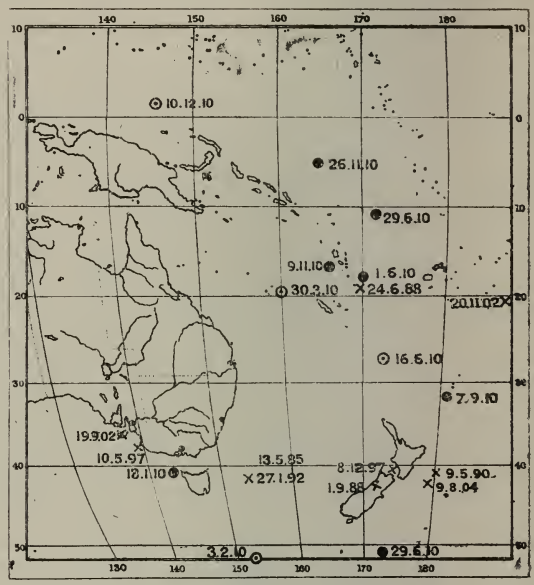


FIG. 1.

Earthquake-origins in the South-west Pacific, 1910.

(G. Hogben.)

● Approximate epicentrum.
⊙ Probable epicentrum.
× Origins previously found.

The origin in each case may, of course, have been a more or less extensive mass below the epicentrum indicated on the map (fig. 1). The map also shows the positions of previously ascertained origins in Australasia.

Date.	Position of Epicentrum.			Remarks.
1910.	Lat.	Long.		
13 Jan. ..	41° S.	143° E.	Approximate..	Not recorded in Europe or other distant stations.
3 Feb. ..	52° S.	153° E.	Probable ..	Recorded at near and distant stations.
30 March ..	19° S.	160° E.	,, ..	Ditto.
1 June ..	18° S.	170° E.	Approximate..	,,
16 ,, ..	27° S.	173° E.	Probable ..	,,
29 ,, (*a*) ..	11° S.	172° E.	Approximate..	,,
29 ,, (*b*) ..	51° S.	173½° E.	,, ..	Between Campbell Islands and Antipodes Islands. All stations.
7 Sept. ..	32° S.	179° W.	,, ..	All stations.
9 Nov. ..	17° S.	167° E.	,, ..	,,
26 ,, ..	5° S.	165° E.	,, ..	,,
10 Dec. ..	2° N.	146° E.	Probable ..	,,

The most interesting of all these earthquakes is perhaps that of the 9th November, 1910, the origin of which appears to have been below the ocean, a little to the south-west of Espiritu Santo, in the New Hebrides Group.

The ascertained elements of the preliminary tremors of this earthquake with reference to eleven stations are given in the table below.

Earthquake of 9th November, 1910.

(Epicentrum, 17° S. Lat., 167° E. Long. Time at Origin, 6 h. 03·7 min. G.M.C.T.)

Place of Observation, and Instrument.	Latitude.	Longitude.	Arcual Distance from Origin (Kilom.).	Chordal Distance (Kilom.).	Time of P_1 6 h. + min.	V_1 (Arc) Kilom. per min.	V_1 (Chord) Kilom. per min.
Apia (Wiechert) ..	13° 48′ S.	171° 46′ W.	2,296	2,284	06·7	765	761
Sydney (Wiechert and Milne)	33° 56′ S.	151° 12′ E.	2,452	2,436	06·9	766	761
Wellington (Milne)	41° 17′ S.	174° 47′ E.	2,800	2,777	07·35	767	761
Perth (Milne) ..	31° 57′ S.	115° 50′ E.	5,365	5,209	10·6	778	755
Honolulu (Milne) ..	21° 19′ N.	158° 03′ W.	5,711	5,521	10·8	804	778
Batavia (Wiechert)	6° 08′ S.	109° 50′ E.	6,317	6,063	11·7	790	758
Zikawei (Wiechert)	31° 15′ N.	121° 26′ E.	7,235	6,850	12·4	832	781
Victoria, B.C. (Milne)	48° 24′ N.	123° 22′ W.	10,056	9,050	14·6	923	830
Madras (Milne) ..	16° 14′ N.	77° 28′ E.	10,285	9,201	15·1	902	807
Edinburgh (Milne)..	55° 57′ N.	3° 11′ W.	15,667	12,000	22·1	851	652
San Fernando, Cadiz (Milne)	36° 28′ N.	6° 12′ W.	17,889	12,560	22·6	946	665

NOTE.—P_1, preliminary tremors; V_1, velocity of P_1 waves.

It will be seen that in this case there is a closer agreement between the velocities (values of V_1) for paths calculated along the chord than for those calculated along the arc; in other words, that the chords represent a closer approximation to the actual paths than the arcs. (It will be understood that the chord cannot be the actual path of a wave passing through layers of varying density, and subject, therefore, to refraction at the bounding surfaces.)

It will be seen that the velocity (P_1) of waves, calculated along the chord, for places not more than 60° from the origin is about 760 kilometres, per minute; that for places between about 60° and 90° from the origin the chordal velocity is greater; that for distances over 90° it is considerably less.

This enables us to formulate a hypothesis illustrated by the diagram (fig. 2). Disregarding the surface rocks, which I have elsewhere shown to be not more than twenty-five to thirty miles in thickness, we may assume a shell of much greater density about 500 miles in depth (AAA.)

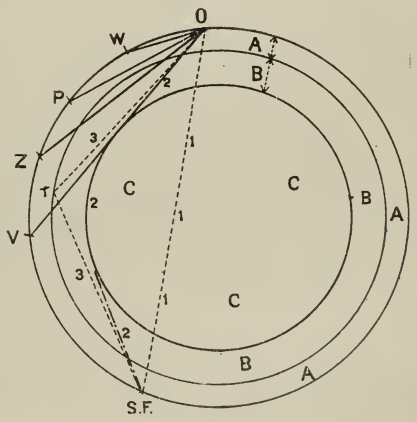


FIG. 2.

Possible Paths of P_1 Waves, 9th November, 1910, to Wellington, OW; Perth, OP; Zikawei, OZ; Victoria (B.C.), OV; San Fernando, 111, or 222, or 3 r 3. O, origin.

and below that a shell of still greater density about 630 miles thick (BBB). Below the last-named shell there seems to be a marked change of physical condition—either the density is much less (which is hardly conceivable) or the centrosphere (CCC) is viscous. I have drawn hypothetically the possible paths of preliminary waves reaching the San Fernando Observatory from the origin: (*a*) They may have been transmitted along a path approximating to the chord 1 1 1, but with greatly reduced speed through the central portion; or (*b*) they may have been transmitted along, or nearly along, the path 2 2 2, as internal surface waves for the middle portion of the path—that is, along the surface of the centrosphere; or (*c*) they may have been transmitted along a path 3 *r* 3—that is, along the chords O *r*, *r* S.F., being reflected at *r*.

I put this forward as a mere trial hypothesis, based upon the examination of the records of one earthquake, and examined only partially by other records. It is, however, I think, worth careful examination in the light of all the available data of other earthquakes. I propose to make such an examination (which may last months, or even years), and hope to place the results, whether positive or negative, before you on a future occasion.

I should like to express my appreciation of the kindness of the observers in charge of the Milne seismographs at Sydney, Adelaide, Perth, and Christchurch in sending me copies of their records and seismograms. I regret that I have been unable to obtain any of the records of the instrument at the Melbourne Observatory.

Art. XIV. — *Fluctuations in the Level of the Water in some Artesian Wells in the Christchurch Area.*

By F. W. Hilgendorf, M.A., D.Sc.

[*Read before the Philosophical Institute of Canterbury, 6th December, 1911.*]

As part of the activities of the Artesian Wells Committee of the Canterbury Philosophical Institute, observations on fluctuations in the static height of the water in some flowing wells in the Christchurch artesian area were undertaken early in January, 1910. The records of the wells will be dealt with separately.

(1.) Lincoln College Well.

This well is 341 ft. deep from the ground-level, which is 38 ft. above sea-level. It is a 2 in. pipe, and was sunk in 1893. The water rises to about 8 ft. above ground-level.

There are in the district four other wells of approximately the same depth. The nearest of these is about three-quarters of a mile away, and the next nearest over a mile away.

The observations were taken by means of a glass tube attached to a tap bored into the well-pipe, and the tube was backed by a wooden scale marked in centimetres. The hydraulic rams worked by the well were shut off for the purpose of taking the observations, and the water in the tube

allowed to come to rest. The oscillations ceased in about five minutes. A loose-fitting plug was placed in the top of both the well-pipe and glass tube to prevent the wind blowing down and agitating the level of the water.

The readings were taken at 8 a.m. and 5 p.m., and only eleven readings were missed during the year.

The Monthly Fluctuation.

Disregarding the minor variations, the well sank gradually from January to June, during which time it fell 24 cm., or 10 in. On the 10th June and the following days, 6 in. of rain fell at Lincoln, and the well then started to rise, and continued to do so for four months, during which time it rose 66 cm., or 2 ft. 2½ in., on an average of the weekly readings. The lowest individual reading was 71·2 cm. on the 4th June, and the highest 141·5 cm. on the 25th September and the 17th October. This gives a maximum difference of 70·3 cm., or about 2 ft. 4 in.

The following graph shows the static level of the well for each month during the year, all the readings for the month being averaged to find the level for that month. Below the graph of the static levels there is shown the monthly rainfall at Lincoln in inches.

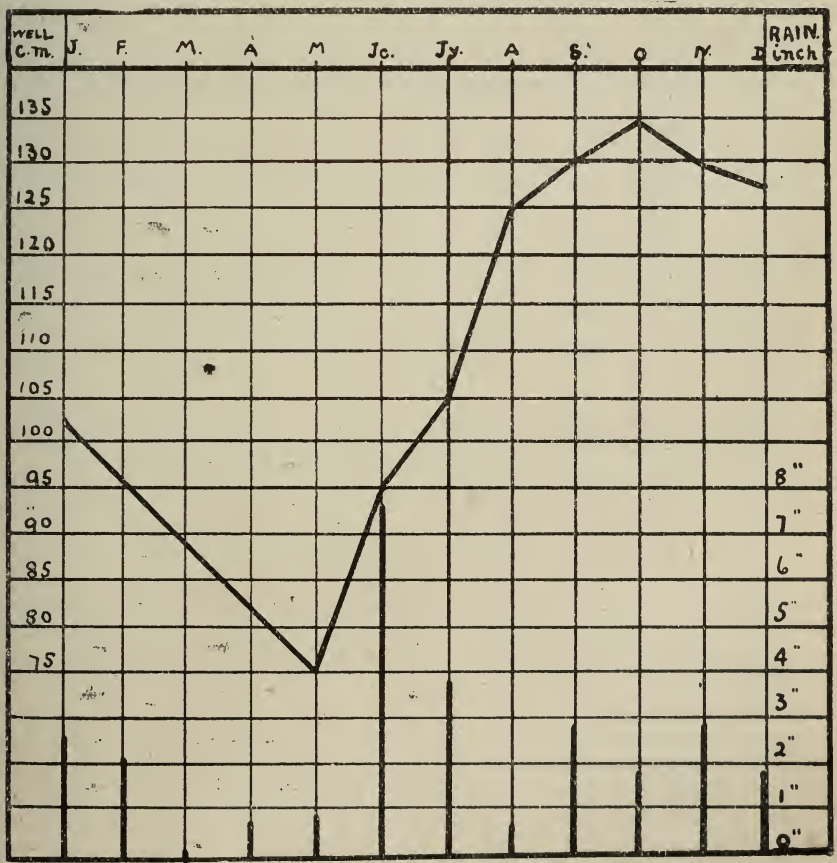


Fig. 1.—Monthly Averages of Height of Well, and Monthly Totals of Rainfall at Lincoln.

A study of this graph shows that the rainfalls from January to May were not enough to balance the water drawn off from the reservoir supplying the well; that the rains in June and July were sufficient to replenish it; that the almost total absence of rain in August was accompanied by a still further rise in the level of the water, possibly indicating that the heavy rainfall of the previous months was still percolating to the reservoir; that the rains of September and October were accompanied by a slight rise, although they were almost exactly equal to the rainfall of January and February, which were accompanied by a fall in the level of the well; and that falls took place in November and December.

These last facts, and also, in part, the rise in August, are probably to be explained by the great amount of evaporation in November, December, January, and February, and its smaller amount in August, September, and October; that the evaporation might have an effect on the fluctuation of the well did not suggest itself to me early enough for me to install evaporation-gauges. It seems probable that the evaporation in the summer months would exceed the rainfall, and thus assist the lowering of the static level of the well; while in August, September, and October the evaporation would be very slight, and thus all the rainfall would be available for replenishment of the reservoir. The following table by Greaves, taken from Warrington's "Physical Properties of the Soil," p. 108, is instructive :—

Evaporation from a Water Surface near London (Average of Fourteen Years).

Month.	Rainfall.	Evaporation.	Month.	Rainfall.	Evaporation.
Jan. ..	2·87	0·76	July ..	1·77	3·44
Feb. ..	1·60	0·60	Aug. ..	2·33	2·85
March ..	1·94	1·07	Sep. ..	2·35	1·61
April ..	1·43	2·10	Oct. ..	2·73	1·06
May ..	2·06	2·75	Nov. ..	2·02	0·71
June ..	2·21	3·14	Dec. ..	2·42	0·57

Total rain, 25·73 in.; total evaporation, 20·66 in.

I think it probable that a graph of the monthly rainfall minus evaporation would approximate the graph of the static level of the well, and I regret that the importance of the evaporation did not occur to me earlier.

This fluctuation of over 2 ft. during the course of the year is very much greater than that of 10 in. recorded by Captain Hutton, but is much less than one mentioned by Mr. Horne, of Leeston, who says that he had there a well which in a dry season was 3 ft. 6 in. below ground-level, and in a very wet season rose to 14 ft. above ground-level. A gravel-pit at Springston about 10 ft. deep is nearly always dry in February, and frequently is full to overflowing in August.

The Weekly Fluctuation.

The following graph of the weekly averages of the readings of the well shows clearly the relation between the static level of the well and the rainfall.

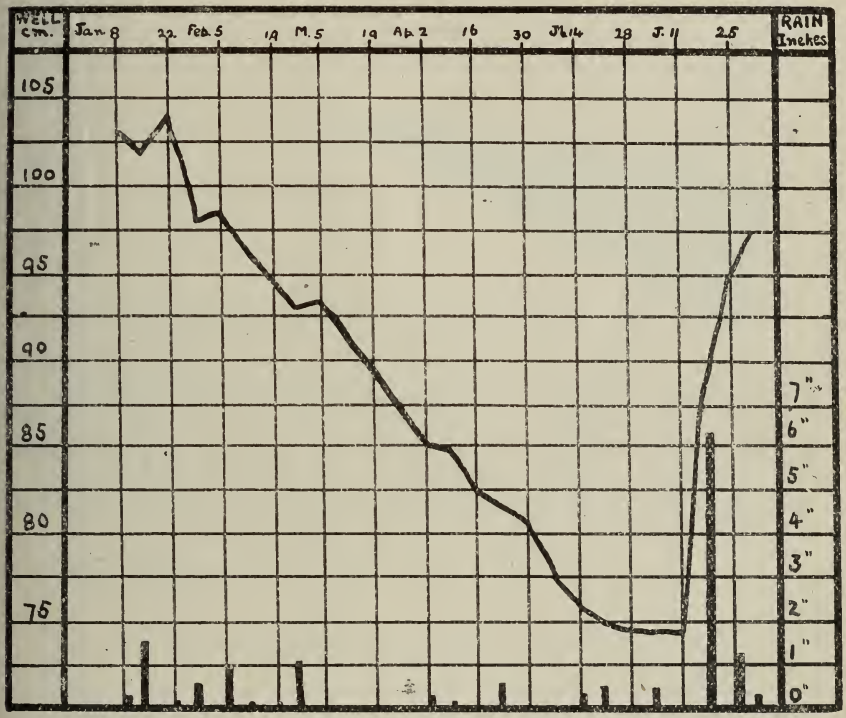


FIG. 2.—WEEKLY AVERAGES OF HEIGHT OF WELL, AND WEEKLY TOTALS OF RAINFALL AT LINCOLN.

It is clear from this graph that the well rises whenever rain falls, and that the rise in the well is approximately proportional to the rainfall. This result was anticipated from the work of Hutton* and Speight,† but it was considered impossible that the rainfall at Lincoln could be responsible for the rise in the well there, since, as before mentioned, the well draws its water from 341 ft. below ground-level.

Lincoln is situated on the Canterbury Plain, fourteen miles from the sea. The plain is about fifty miles wide, and slopes upwards from the sea to the mountains, at whose feet its level is about 1,300 ft. It is composed of a coarse gravel interstratified (especially in its coastal portions near Christchurch) with clay, peat, &c., as described by Speight (*loc. cit.*). On the supposition that the lower strata have been laid down at a steeper angle than those now on the surface, the water-bearing stratum tapped by the Lincoln College well should outcrop on the surface of the plain some miles above Lincoln, and it would probably be the rain falling on this outcrop that would supply the well. This idea is embodied in the following diagrammatic sketch, where the heavy lines show the clay strata between

* Trans. N.Z. Inst., vol. 28, p. 654. † Trans. N.Z. Inst., vol. 43, p. 420.

the shingle. If this were a correct supposition, it was considered possible to locate the outcrop of the water-bearing stratum by means of observing the rainfall at a number of places between Lincoln and the mountains,

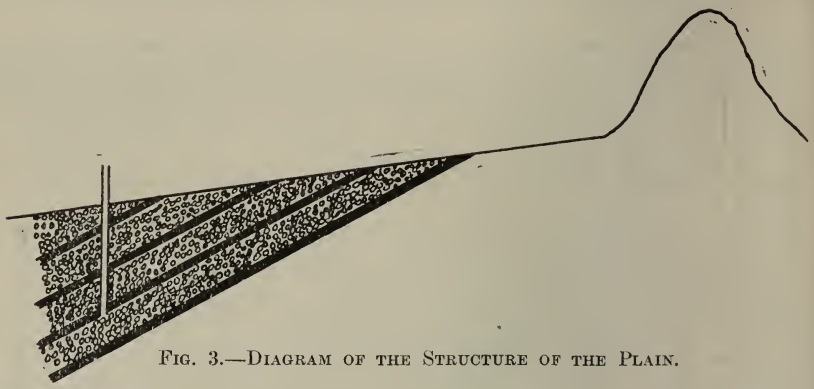


Fig. 3.—Diagram of the Structure of the Plain.

and noting at which places the rainfall most nearly corresponded with the fluctuations in the level of the well. For this purpose rain-gauges were installed or existing installations were used to obtain records of the daily rainfall from the following places: Rolleston, Lawford, Kirwee, Darfield, Hororata, Glenroy, and Mount Torlesse. The positions of these places are shown on the following map, which also shows the two rivers of the district. The slope of the plain is from north-west to south-east.

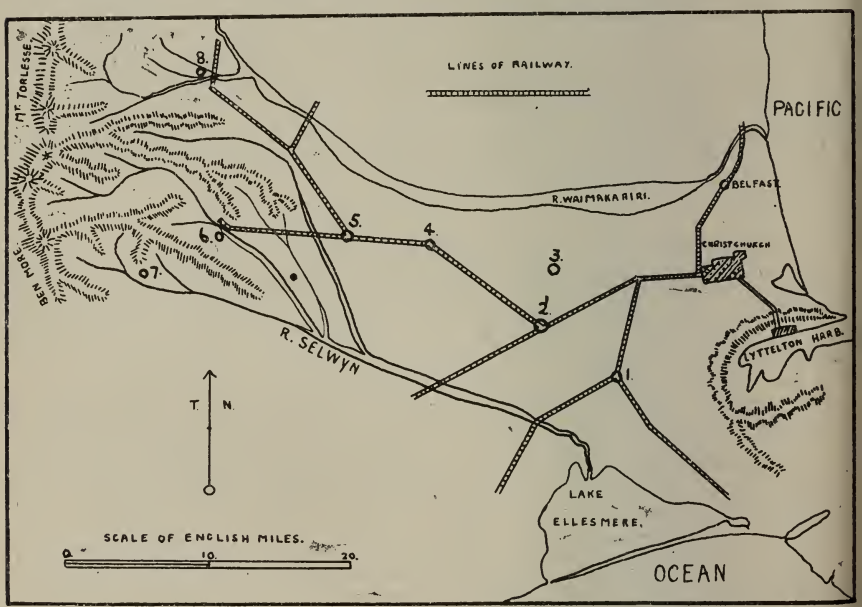


Fig. 4.—Map of Portion of Canterbury Plain, showing Positions of Rain-gauges.

1, Lincoln; 2, Rolleston; 3, Lawford (half-way between Weedon's and West Melton); 4, Kirwee; 5, Darfield; 6, Hororata; 7, Glenroy; 8, Mount Torlesse (two miles above Springfield).

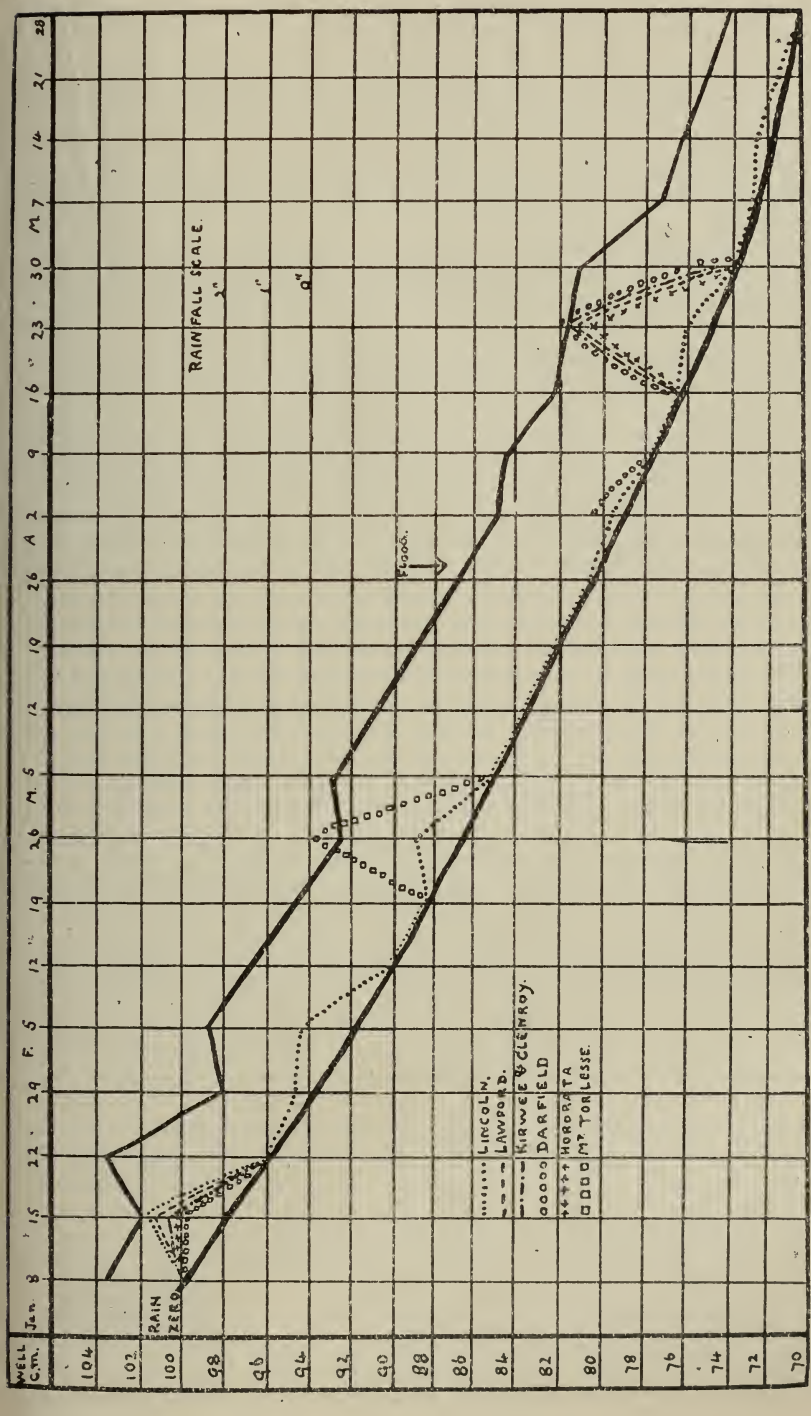


FIG. 5.—WEEKLY AVERAGES OF STATIC LEVEL OF WELL, WITH WEEKLY RAINFALLS FOR DIFFERENT STATIONS.

Unfortunately, all the records did not begin at the beginning of the year, those from Darfield not commencing till the 1st April, and those at Rolleston till the 1st June. Valuable information was thereby lost. The records are, however, complete and accurate for the periods they cover. In the accompanying graph (fig. 5) the averages of all the readings of the well for each week for five months are shown, and underneath them the total weekly rainfalls for each of seven stations, Rolleston readings not having been commenced. Zero for rainfall is made a sloping line, roughly corresponding to the graph of the well, for the purpose of bringing the rainfalls-graph near to that of the well, to facilitate comparison. To simplify the figure, rainfalls are shown for only those weeks from which conclusions may be drawn. The falls of Glenroy and Kirwee were identical for the weeks shown, and therefore these two stations are represented by only a single symbol—viz., dots and dashes.

Starting with the station nearest the mountains—viz., Springfield—if the rainfall at Springfield (squares) for the week ending the 15th January was responsible for the rise of the well shown for the week ending the 22nd January, then also the much heavier rainfall for the week ending the 26th February must have been responsible for the almost imperceptible rise for the week ending the 5th March. These two results are inconsistent, and therefore it may be stated that the rainfall on which the well depends does not fall at Springfield, nor does the water-bearing stratum tapped by the well outcrop there. Similar inconsistencies may be noted for other localities, as follows:—Hororata: In the week ending the 15th January a rainfall of 1 in. is followed by a rise in the well of 1·5 cm., and on the 23rd April a rainfall of 2½ in. is followed by a decline of 1 cm. Glenroy shows inconsistencies for the weeks ending the 15th January and the 23rd April; Darfield for the weeks ending the 2nd and the 23rd April; Kirwee for the weeks ending the 15th January and the 23rd April; and Lawford for the weeks ending the 15th January and the 23rd April. But when we come to examine the rainfall at Lincoln, and compare that with the subsequent rises, or arrests of the decline of the graph of the well, a remarkable degree of consistency is disclosed. The graph of the static level of the well is as nearly parallel to that of the Lincoln rainfall as could possibly be expected under the circumstances, and, being given the rise of the well due to the rainfall of the 15th January, the graph of the one could be constructed with reasonable accuracy from that of the other. From this it is evident that the stratum tapped by the well outcrops in a district with a rainfall during the months shown almost exactly equal to that of Lincoln. None of the stations recording for me shows such an equality, and so it seems evident that the water-bearing stratum under consideration outcrops nearer to Lincoln than to the nearest of the stations. That station is Lawford, nine miles away, and so one would probably be safe in saying that the stratum of shingle 341 ft. under the surface at Lincoln reaches the surface seven miles or less up the plains. This would place the outcrop somewhere about Rolleston—a district noted for its loose shingly soil, directly underlaid by coarse gravels, with no interposing layer of clay. Such country is absorptive of water in the highest degree, and an ideal catching-area for an underground water-supply.

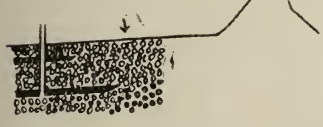
The surface of the land at Rolleston is 134 ft. above that at Lincoln. The water-bearing stratum then rises 475 ft. in seven miles, or about 68 ft. to the mile. The surface of the plains near their upper limit has a fall of about 60 ft. to the mile, while between Rolleston and Lincoln it is only

20 ft. to the mile. At the time that the fall on the surface of the plains between Rolleston and Lincoln was 68 ft. to the mile—that is, when our water-bearing stratum was deposited—the whole plain must have had a much steeper gradient than at present. This would probably be due to the much greater supply of waste to the above-gorge waters of the rivers, so that in those times the present plains would have been much more like the present-day shingle fans than like plains. That the gradient of the plains was once much steeper than now is proved by the high terraces round Woodstock, and by Racecourse Hill, a residual shingle mound some 60 ft. high. The cutting into their beds of the present rivers is merely a continuation of the process of lessening the gradient of the plain, the bed of the Waimakariri being virtually level with the plains at their lower edge, and over 300 ft. below them at their upper limit. It is therefore in accord with what I suppose would be the expectations of geologists that at one time the surface of the plains should be much more steeply inclined than now, but that the supply of waste should be so great as to form a deposit sloping nearly 70 ft. to the mile forty miles away from the gorge is perhaps noteworthy.*

It was stated above as evident that the collecting-ground for the well is nearer Lincoln than the nearest rainfall-station is. On the part of one unacquainted with the country, a possible objection to this is that the collecting-ground might equally well be more distant from Lincoln than the farthest station is. The country between Springfield and the West Coast, however, consists of mountains of greywackes and slates quite impervious to water in large quantities, and, in any case, this water would percolate out into the rivers flowing at the base of the mountains. The amount of water in the Waimakariri is, moreover, a gauge of the amount of rain falling on these mountains, and I have been so fortunate as to be supplied with daily readings of the height of the river during several months. Most of the floods that my records show occurred nearly contemporaneously with considerable rainfalls on the plains, and the subsequent rises of the well could not, therefore, be stated as dependent on, or independent of, the rises in the river. On the 23rd March, however (see the arrow-head in fig. 5), there was a heavy flood, sufficient to stop the mails at the Bealey, but, as fig. 5 shows, there was no sign of any rise or arrest of the decline of the well until rain fell in the second week after the flood.

Although it is impossible that the rain falling on the mountains should directly find its way into the water-bearing stratum tapped by the well, it seemed quite possible that after reaching the river the water might percolate into such a stratum where the river runs across its outcrop. This, indeed, is probably the common opinion held; but the observations made do not support the supposition, as far as the well at Lincoln goes. The observations on

* At the meeting at which this paper was read Mr. Speight pointed out that the conclusion reached here is probably incorrect. His observations on the strata pierced by wells near Christchurch shows that the deep-lying strata are at practically the same slope as the present surface of the plain. It is a matter of common observation that clay strata, though common near Christchurch, disappear farther up the plains, and it is probable that Rolleston marks the distance from Lincoln at which the clay stratum over the water-bearing stratum fades away, rather than the outcrop of a series of strata regular in thickness from the base of the well to the outcrop. This idea is shown in the accompanying diagrammatic sketch, where the arrow-head shows the position of Rolleston. Mr. Speight's interpretation of the facts seems to me correct, and invalidates the conclusions above drawn as to the former slope of the surface of the plains.



the height of the river were made with great care, readings being taken each day to the nearest inch. On compariosn with the graph of the static level of the well no agreement could be observed in any case, and the perfect indifference of the well to the flood on the 23rd March is typical of this.

Another possible objection to the placing of the outcrop at Rolleston is that this has been done almost entirely on the slight rainfall at Lincoln and the heavier rainfall at all other stations for the week ending the 23rd April. This is quite true; but occasions on which the rainfall is markedly different at different points on the plains are rare, and some years of observations may be needed to secure a confirmation, by this method, of the conclusion drawn. In the meantime, the accuracy of the rainfall recorded at the various up-plain stations is sufficiently substantiated by their mutual agreement, and the accuracy of the record at Lincoln by comparison with that made by three other observers in the neighbourhood.

The Daily Fluctuation.

Even during long periods of steady decline or rise of the well its static level showed comparatively large daily variations. On some occasions it would rise 3 in. in twenty-four hours (without rain), and would fall by the same or a greater amount by the succeeding morning. Variations of 2 in. on successive mornings were common, and usually the morning readings showed variations of over 1 in. The irregularities of the static level within short periods of time during which no rain fell led to an attempt to correlate the variations in the well with those of the barometric pressure of the air. At length it was found that by turning the barometer-readings upside down and multiplying them by four a marked degree of harmony between the graph of the well and that of the barometer was displayed—a harmony so consistent as to establish the fact that the level of the water in the well and that of the mercury in the barometer are influenced by the same causes. The accompanying graph (fig. 6) shows this clearly.

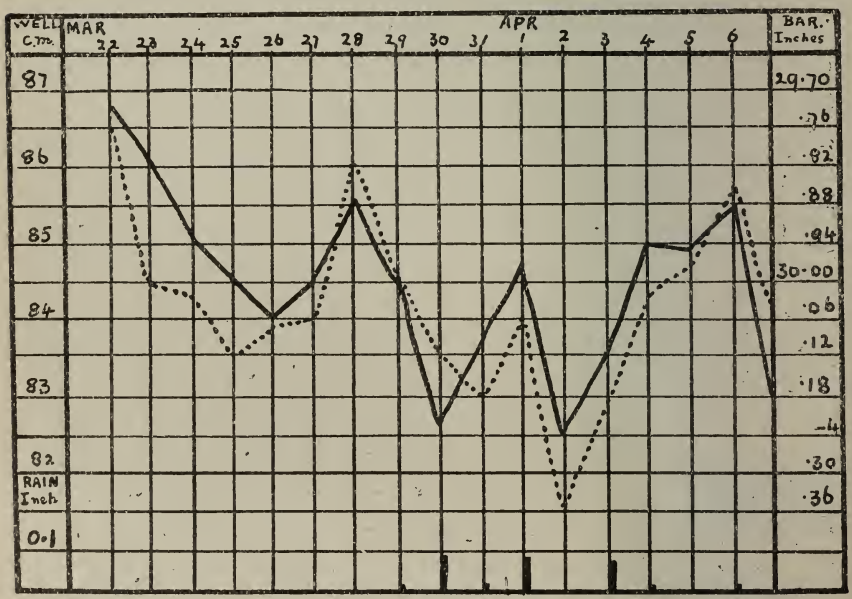


Fig. 6.—Daily Readings of Well, Barometer, and Rainfall at Lincoln.

The graph of the well is shown by the full line, and its variations in centimetres; that of the barometer by a dotted line, and its variations in inches. It will be observed that the scale for the well increases upwards, and that for the barometer downwards; further, the space between 29·82 in. and 30·30 in. on the barometer scale (virtually ½ in.) is the same as the space between 86 and 82 on the well scale—that is, 4 centimetres (virtually 2 in.). This means that the close agreement of the two graphs seen in fig. 6 has been obtained by turning the barometer-readings upside down and multiplying by four, as above stated. Figure 6 is a portion of a graph that was constructed for the whole year for the purpose of establishing the agreement between the fluctuations of the well and the barometer.

The section 22nd March to 8th April was chosen for illustration because it is fairly typical of the whole graph, and because there is no complication due to rainfall. There were showers on the 29th, 30th, and 31st March, and on the 1st, 3rd, 4th, and 6th April, but the three heaviest of these were only 0·07 in., 0·08 in., and 0·09 in., and the remaining were 0·01 in. each. These numerous rains, the greatest of which did not reach 0·1 in., cannot be suspected of influencing the graph of the well, since in any case the well does not always rise after the rainfalls shown.

That a low barometer is accompanied by a rise in the static level of shallow wells has been excellently demonstrated by F. H. King, and for artesians is recorded in the following sentence occurring in an article by Professor J. W. Gregory in the "Journal of the Royal Geographical Society" for August, 1911, p. 171: "The Hon. E. W. Lamb kindly tells me that an increased flow has been observed in some of the wells of New South Wales at times of low barometric pressure. The increased flow from springs when the barometer is low is a well-known phenomenon which has been established, for example, by the work of Mr. Baldwin Latham near Croydon. The increase is no doubt due to gas-pressure, the gases dissolved in the water expanding when the atmospheric pressure is reduced. Mr. Latham's evidence therefore shows that gas-pressure acts even on wells of which the flow is mainly determined by ordinary water-pressure."

I have examined this theory of the rise of wells under diminished atmospheric pressure. It appears to assume that water is compressible, or, at least, that the gases within the water are compressible. This, of course, is not so. If the pressure is diminished the gases will remain dissolved if the water is not already saturated with them, and if the water is saturated the gases will come out of solution and form bubbles. The water in the College well is saturated, containing 26·50 c.c. of gases per litre at N.T.P., made up as follows: Carbon-dioxide, 1·07 c.c. per litre; oxygen, 4·29 c.c. per litre; nitrogen, 21·14 c.c. per litre.

It must be further remembered that the volume of a gas absorbed by water is independent of the pressure, since, although doubling the pressure doubles the mass of the gas absorbed, the same doubling of the pressure halves its volume. If, then, the pressure were suddenly diminished the volume of gases liberated would be proportional to the diminution of pressure, and *if the gases remained in suspension in the water* the volume of the water would be increased.

Calculation shows that with a diminution of atmospheric pressure from 30 in. to 28 in. of mercury—that is, from 15 lb. to 14 lb. per square inch—the bubbles of gas liberated in this well 340 ft. deep would raise its level by 1·8 in. By observation, the rise of the well under such a barometric fall amounts to 8 in., and therefore the liberation of gases

theory is insufficient to explain the fluctuations of the well with the fluctuations of the barometer as observed at Lincoln.

In the above calculation it was assumed that the gas-bubbles formed remained in the water, but since the changes in pressure are very gradual, since the water is always flowing upward, and since one-third of the total liberation of gases takes place in the top 30 ft., it is evident that the bubbles of gas must escape, and therefore cannot raise the level of the water anything like the 1·8 in. calculated above, much less raise it the 8 in. recorded by the observations.

An explanation of the rise of the well with decrease of barometric pressure more in accordance with the observed facts is as follows: Water must continually be drawn away from the water-table at the outcrop by the flow of water from the well, and more particularly the flow at the lower outcrop of the stratum under the sea. Well-sinkers find that the water runs in certain fairly defined streams in the water-bearing strata, and at Islington is to be seen a very large and freely moving underground stream running through the shingle at the bottom of an open well 42 ft. deep. Small particles of sand have therefore been removed from these strata, and the water can move freely; but the land over the water-table at the outcrop is not thus freed from small particles, and, as the water is removed, the air has a difficulty in following the water downwards, and so a partial vacuum is set up over the water at the outcrop, after the manner of the production of a Sprengel's vacuum. The water in the water-bearing stratum and the water in the well-pipe now form the two arms of a water-barometer, at the open end of which the observations are being taken. Since the open end is being observed, the water goes up when the mercurial barometer goes down; since it is a water-barometer, it should go up thirteen times as much as a mercurial barometer falls, but since the vacuum at its closed end is not perfect its motion is not so great as this. It goes up four times as much as the barometer goes down, thus indicating that the vacuum over the water-table at the outcrop is about one-third of a true vacuum—*i.e.*, that the air-pressure amounts to about 10 lb. instead of 15 lb. to the square inch.*

The Evening Rise.

That the well at the Museum in Christchurch is usually higher in the evening than in the morning is noted both by Captain Hutton (*loc. cit.*) and by Mr. Speight (*loc. cit.*). By both these writers it was thought possible that this evening rise might be caused by the shutting-off of other wells of the same stratum in the near neighbourhood in the afternoon, although Mr. Speight is not inclined to accept this explanation. That the shutting-off of adjacent wells causes any particular well to rise is proved by Captain Hutton's observation that the Museum well

* This explanation met with a great deal of adverse criticism at the meeting at which the paper was read. Mr. Hogg and Mr. Page suggested that changes of aerial pressure would be felt directly by the water in the open pipe, but only slowly by the water at the outcrop, owing to the fact that the air superincumbent on the water there is entangled among particles of soil. This, I find, is also King's explanation ("The Soil," p. 180). Warrington ("The Physics of the Soil," p. 129) appears to prefer the explanation attributed to King in the present paper in the section on "The Evening Rise"—viz., with a falling barometer the air in the soil expands, and the water filling the interstices above the water-level is expelled, and causes a rise in the water-level of the soil. Either of these explanations is perhaps sufficient to account for the fluctuations observed, but I still regard my explanation as a possible, and even a probable, one.

was constantly higher on Sundays than on Saturdays and Mondays, and that even a public holiday was accompanied by a decisive rise in the well under observation. Mr. Dobson, Christchurch City Engineer, has informed me that the installation of a city water-supply has been followed by the breaking-out of springs in numerous places about the city, and he explains this as follows: In the early days of the city's life wells sunk on some of the higher ground had a static level of 1 ft or 2 ft. above the ground. As more and more wells were sunk to the same stratum, the static level was lowered; those on ground a foot or two lower continued to flow, but those on higher ground had their static level reduced to below that of the ground, ceased to flow, were abandoned and forgotten, and their mouths covered up. On the installation of the city supply many users of artesian water stopped their flowing wells, the static level recovered itself, and the old abandoned wells recommenced their flow, sometimes in such inconvenient places as cellars, public parks, and important streets. The explanation seems very probable, and emphasizes the interdependence of wells sunk to the same stratum. Mr. Dobson further informs me that he on one occasion fitted a pump to a particular flowing well, and started to work the pump with a steam-engine, with the result that as long as the pump was at work all the wells in the neighbourhood ceased to flow. It was primarily to escape this interference of one well with others in its neighbourhood that I commenced observations on the comparatively isolated well at Lincoln, and it was the evening rise that was the original object of the inquiry. As stated before, there are only four other wells of the same depth as the College well within a radius of two miles; the nearest of these is three-quarters of a mile away, and I felt that I could secure from the owners of all these wells any co-operation necessary for my observations.

The object for which the investigation was undertaken has, however, not been accomplished, since no light has been thrown on the evening rise, except that it does exist, and that it is not caused by the shutting-off of neighbouring wells. Out of the fifty-one weeks during which the observations have been made, the weekly averages of the evening readings have been higher than those of the morning readings on thirty-six weeks, equal on four weeks, and lower on eleven weeks. The following table shows the averages of all the readings of each month, with the evening rise:—

Month.	Morning Reading.	Evening Reading.	Evening Rise.
January ..	101·21	101·60	0·39 cm.
February ..	95·08	95·20	0·12 cm.
March	88·47	88·66	0·19 cm.
April	82·10	82·40	0·30 cm.
May	75·60	75·80	0·20 cm.
June	95·10	95·30	0·20 cm.
July	104·30	105·20	0·90 cm.
August	130·16	131·36	1·20 cm.
September ..	136·84	137·11	0·27 cm.
October ..	137·97	137·92	— 0·05 cm.
November ..	134·38	134·80	0·42 cm.
Average ..	107·38	107·76	0·38 cm.

The evening rise is thus fairly well marked. During the months of October and November I personally secured that all the wells in the neighbourhood were running continuously, with the exception of one (three-quarters of a mile away) which its owner was good enough to shut off from 7 to 9 a.m. and 4 to 6 p.m. every day. The readings during these two months were taken exactly at 8.30 a.m. and 5.30 p.m., so that the well had an hour and a half to recover any disturbance that might have been set up by the well whose flow was intermittent. That this intermittently flowing well could have any effect on the College well, so far away, is questionable, and, in any case, it was not (even during the months I did not keep special control of it) usually running in the morning or usually shut off in the afternoon. The interference of neighbouring wells may therefore be rejected as a cause of the evening rise.

Any constant variations in temperature are similarly to be rejected. I kept a record of the temperature of the flowing water just as it emerged from the ground from the 10th to the 30th October. The temperature varied from 12·81° C. to 12·90° C., and this variation was more probably due to the effect of the air on the stem of the thermometer than that of the water on its bulb. In any case, the temperature never showed any disposition to be regularly higher in the evening than in the morning, and, if it had, a much greater rise of temperature would have been needed to cause sufficient expansion of the water (inside an iron pipe, on which the scale was carried) to account for the observed rise in the static level. The water in the gauge-glass is, however, practically the same water all the time, and therefore takes on to a considerable degree the temperature of the atmosphere. It varied from 10·0° C. to 23·9° C. during the month of October. The higher readings were, however, on all but three occasions obtained in the morning, owing to the sun shining on the gauge-glass and above-ground portion of the well-tube in the morning and not in the evening; indeed, the highest reading (23·9° C.) was obtained in the morning, and on the same evening the temperature was 12·0° C. In any case, an average evening rise of temperature of about 25° C. would be needed to cause a 4 ft. column of water (in a glass tube with an independent scale) to expand sufficiently to account for the observed rise in the static level. A shrinkage of the wooden scale in the evening would also explain the rise; but means to detect and measure this, if it occurred, were not at hand, and the line of investigation held little promise. During the months of October and November, also, records were kept of the barometric pressure in the mornings and evenings, and it was found that the readings were, on the average, lower in the evenings than the mornings. The amount of the decrease in the barometric height in the evenings was 0·07 in., sufficient to account for a rise in the well of 0·56 cm., or more than the actually observed rise. The barometric observations were, however, taken on an aneroid barograph, the mercurial barometer unfortunately being out of repair. There is, I suppose, no question that the temperature of a living-room is higher in the evenings than the mornings, and I have rather good proof that increase of temperature depresses the record made by an aneroid barograph. The apparent fall of the barometer each evening is, therefore, only a temperature effect, and

cannot be used to explain the rise of the well. This fact is emphasized by the following graph (fig. 7), obtained in Invercargill in 1903: it is perhaps sufficiently striking to merit publication.

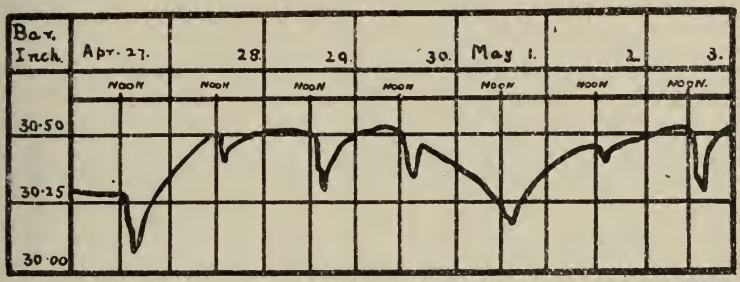


FIG. 7. — BAROGRAM SHOWING DEPRESSIONS DUE TO RISE IN TEMPERATURE AT NOON.

During a temporary absence from home I placed the barograph in a window, so that an observer could read its records without entering the house. The window happened to face north-north-west, and the sun fell on the instrument just after midday. On each day the graph falls nearly 0·25 in. as soon as the sun strikes the instrument, and it rises again about 5 o'clock, when the sun passes off. The small fall of the barometric pressure recorded for the evenings during the present observation is therefore not reliable, and cannot be used to explain the evening rise of the well.

No explanation of this phenomenon can, therefore, be offered as the result of these observations. Mr. Speight has suggested to me that it might possibly be correlated with the expansion of the earth by the heating effect of the sun, and the passing of an earth-wave or earth-heave towards the sun as it sets, as explained by Milne. No observations or calculations have been made to test the probability of this suggestion.

F. H. King (*vide* "The Soil," p. 162, &c.) found a morning rise in his shallow wells, and this is explained by the fact that the soil-temperature is highest in the morning, and that the expansion of the soil-air expels some of the soil-water so that it reaches and raises the water-table and thus the well. It is possible that observations might show that at the outcrop of our water-bearing stratum the soil-temperature is higher in the evening, and this would explain the evening rise. This is another of the numerous points on which no observations were made.

(2.) THE MUSEUM WELL.

This is a flowing well, 190 ft. deep, situated at the Canterbury Museum, Christchurch. It is the deep well whose behaviour was recorded by Captain Hutton (*loc. cit.*), and Mr. Speight made further observations on it during 1910 and 1911. I have worked up both Hutton's and Speight's observations in the same way as I have my own, comparing them with the barometer-readings, taking out weekly and monthly averages, &c., and have found the following facts: (1.) The major fluctuations in the static level of the well are small, the greatest annual variation recorded during the two series of observations being $10\frac{1}{2}$ in., as compared with 2 ft. 4 in. in the Lincoln College well. (2.) Its level is changed by rain in the same

manner and to the same degree as in the Lincoln well, but there is a much less decline in its static level during a similar period of almost similar rain. (3.) There is no sign of floods in the Waimakariri influencing the well. (4.) There is no sign of agreement between the graph of the well and that of the barometer, however the latter is manipulated. (5.) There is an evening rise. Points (2) and (3) are illustrated by the following graph (fig. 8), which is comparable to fig. 2, both graphs being on the same scale.

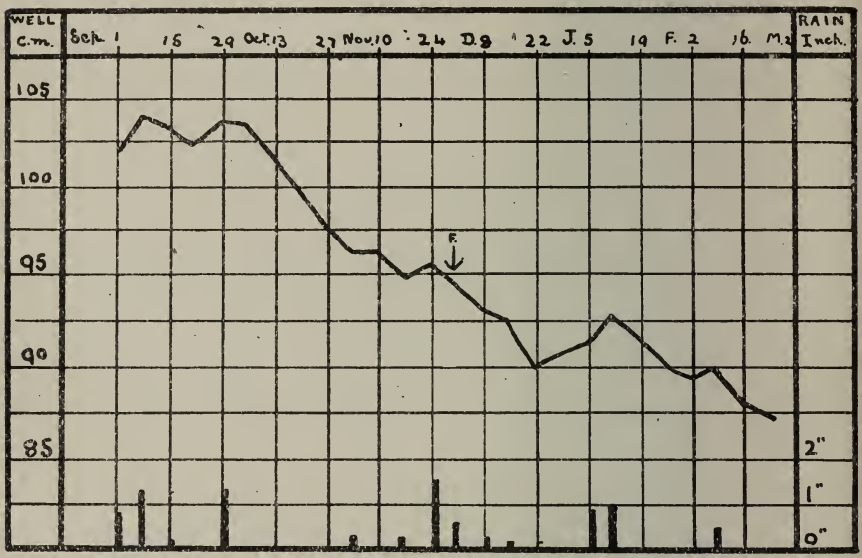


Fig. 8.—Weekly Averages of Height of Museum Well and Weekly Totals of Rainfall at Lincoln (1894–95).

The want of agreement between the graph of the well and that of the barometer may be explained either as the result of the Waimakariri assisting the rainfall to supply the well, or as the result of the interference of neighbouring wells. That such interference does take place has been shown in a previous section.

The lack of pronounced decline during a comparatively rainless period, and the smallness of the annual variation (10½ in.), opens up seriously the question as to whether the Waimakariri does assist the supply of the flowing wells in Christchurch. In favour of the rainfall being the sole source of supply are the following facts: (1) The rise of the well after rain; (2) the absence of effect of even the greatest floods on the river (see fig. 8, 1st December); (3) the diminution of the static level of the wells as each additional well is put down. The Museum well has fallen 4½ ft. in fifteen years, and there is a generally expressed opinion that all the wells in the town are similarly affected. This would be the natural effect if there were a restricted supply of water, such as a rainfall of 25 in. affords. If the lowering of the static level of the wells is an indication of the lowering of the water in the water-table at the outcrop (and it is difficult to suppose otherwise), then the wells in the town are robbing the crops in the country of the supply of water that they should receive by capillary rise, a matter of some importance on light shingly ground.

It has been often asserted by myself, along with others, that it is inconceivable that the rainfall should supply all the water outflowing at the Christchurch wells, but I have made a calculation that, whatever its faults, makes the case at least not inconceivable.

Population of Christchurch suburbs within the artesian areas—*i.e.*, from Sockburn to New Brighton and from Papanui to the Port Hills—86,661 (say)		90,000
Gallons of water used per capita per day, including hydraulic lifts and cranes, street- and garden-watering—		
Auckland (1910)	58	
Wellington (maximum)	60	
Dunedin (maximum)	61½	
Say, average for Christchurch (where street-watering comes from river)		60
Two rams at College lift water an average of 22½ ft., and waste water is seven times that pumped. As this is above average height, we may say proportion of water used to that wasted		One-tenth.
Then, total water drawn from artesians in Christchurch area per year $= \frac{90{,}000 \times 60 \times 11 \times 365 \times 10}{2{,}240}$		96,251,760 tons.

Again,—

Population having been taken as from Sockburn to New Brighton—	
Length of catchment-area	10 miles.
First-stratum wells outcrop two miles up plain (Speight); deep wells (450 ft.) outcrop about eight miles away; ∴ width of catchment-area (about)	6 miles.
Average rainfall	25 inches.
1 in. of rain = in tons per acre	101
Then rain falling on catchment-area per year $= 10 \times 6 \times 640 \times 101 \times 25$	96,960,000 tons.

If there is any approximation to accuracy in this calculation, then each additional well put down to any of the strata at present in use can receive its water only by robbing its neighbours, a condition of affairs that, in the upper strata has long ago been reached. As for the lower strata they have probably not been largely drawn on so far, and there is every reason to suppose that there are still lower strata available but still untouched.

In favour of the Waimakariri assisting the water-supply are these facts: (1.) Water does undoubtedly percolate from the beds of some of the rivers, as stated by Speight (*loc. cit.*), and I am able to add that near Bealey a considerable amount of the Waimakariri flows underground. This water is almost certain to leak into every porous bed, especially where the thin deposit of silt that forms on the river's bed has been removed by scour. (2.) The great degree of constancy of the Christchurch supply, and the smallness of the annual variation in the Museum well during the three periods it has been under observation. I should be inclined to think that water from the river does assist the Christchurch wells in some degree, but the Lincoln well in no degree; but a longer period of observations would be necessary to establish any opinion on the matter.

(3.) The Belfast Well.

This well is situated at the Canterbury Frozen Meat Company's works at Belfast, ten miles north of Christchurch, and within a mile of the Waimakariri. The well was sunk in 1896, and is 96 ft. deep. It is not a flowing well, but opens into a concrete sump, in which the water stands about 4 ft. below the surface. Its construction seems to preclude any surface drainage. Observations were made on it by Mr. L. P. Symes from the 14th October to the 1st December, 1911. The controlling factor influencing its fluctuations seems to be the level of the Waimakariri, as the following graph shows. The heights of the river are those noted at Bealey on the day before they are entered on the graph, as the water in the river takes eighteen hours to flow from Bealey to Belfast.

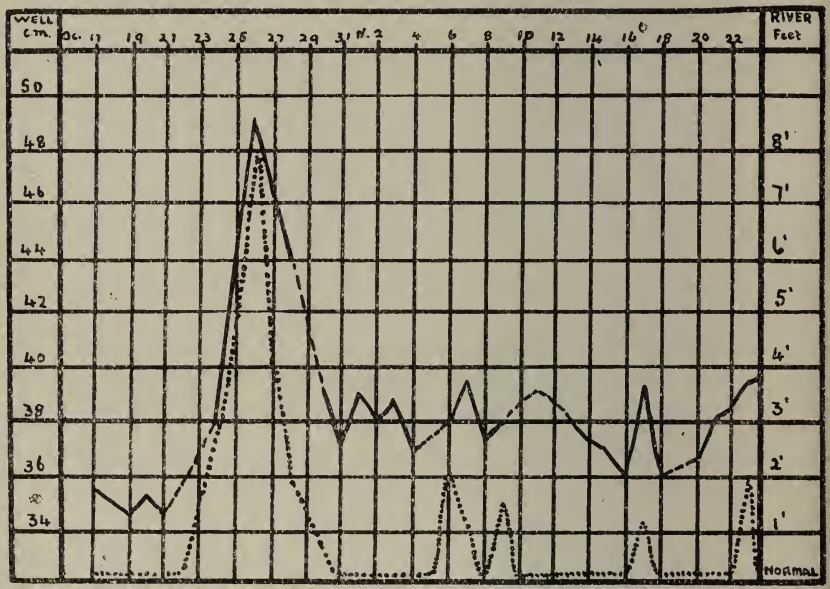


Fig. 9. — Graph of Well at Belfast (Full Line) in Centimetres, and of Waimakariri (Dotted Line) in Feet.

Conclusions.

The well at Lincoln depends for its supply almost entirely on rainfall. The wells in Christchurch depend on rainfall, probably assisted by percolation from the Waimakariri. The wells at Belfast depend chiefly or entirely on the Waimakariri. The rain supplying the wells of present depth falls on the plains comparatively close at hand—say, within ten miles of the town. The discharge from the wells probably lowers the water-table in the country. The barometric pressure influences the wells.

At the close of a paper that is largely a compilation of the work of others I have a long list of helpers to whom to offer thanks. Mr. Speight and Mr. Symes have been good enough to offer valuable suggestions during the course of the work. The Council of the Canterbury Philosophical Institute has voted money for apparatus. Many of the students at Lincoln College, Mr. Speight, Mr. Symes, His Lordship Bishop Grimes, Mr. Crump, and the verger of the Presbytery at Lincoln, have either taken well-

observations for me or definitely placed wells at my disposal. Mr. Gray has supplied analyses of the gaseous contents of well-waters. Mr. W. Paine, telegraphist at the Bealey, has made for me very careful measurements of the height of the Waimakariri. The following have supplied me with rainfall records either for short periods or for the whole year: Messrs. G. Gray and G. Rennie at Lincoln, J. Brunton and R. Ellis at Rolleston, Griffith Smith at Lawford, J. Wilson at Kirwee, J. Reid Wilson at Darfield, G. Hall at Hororata, W. Hall and G. C. Hunt at Glenroy, P. H. Johnson at Mount Torlesse, and, finally, the Government Meteorologist for several stations. Mr. Hogg was kind enough to make the calculation concerning the alteration in the volumes of the dissolved gases under changes of pressure, and Dr. Evans and Mr. McLeod to provide material for apparatus. To all these I beg to offer my thanks, as without their co-operation this paper could not have been written in its present form. I have also to acknowledge the assistance given by the observations made by the late Captain Hutton.

ART. XV.—*A New Genus and some New Species of Plants.*

By T. F. CHEESEMAN, F.L.S., F.Z.S., Curator of the Auckland Museum.

[*Read before the Auckland Institute, 28th November, 1911.*]

1. Alectryon grandis Cheesem. sp. nov.

Arbor 15-pedalis et ultra; ramulis sericeo- et ferrugineo-pubescentibus. Folia pinnata, alterna, breviter petiolata, 22–30 cm. longa; foliola 2–3-juga, brevissime petiolata, late oblonga vel ovato-oblonga, obtusa vel subacuta, 10–18 cm. longa, 5–9 cm. lata, praeter costam venasque primarias plus minusve sericeo-pubescentia; venis ultimis conspicue reticulatis, subtus elevatis. Flores ignoti.

Hab.—Cliffs on the north side of the Three Kings Islands; a single small clump alone seen. *T. F. C.*

This is the plant referred to at page 103 of the Manual under the name of *Alectryon excelsum* var. *grandis*. Although no doubt existed as to its being a distinct species, I have deferred describing it as such, in the hope that some visitor to the Three Kings Islands might return with flowering specimens. But, as twenty-two years have elapsed since its original discovery without producing any additional information, it seems advisable to publish it without further delay. As the islands are now visited at least once every year, I trust that the publicity drawn to the plant may result in its rediscovery.

A. grandis can be distinguished from *A. excelsum* without the slightest difficulty by the small number of leaflets to each leaf, and by their shape and much greater size. In *A. excelsum* the leaflets are 2–4 in. long, and are ovate-lanceolate in shape; whereas in *A. grandis* they are 4–7 in. in length, and are broadly oblong or ovate-oblong. They are also firmer in texture, and much more obtuse.

2. **Coxella** Cheesem. et Hemsl. in Illustr. N.Z. Flora, t. 64 (ined.), nov. gen.

Herba erecta, perennis, glabra. Folia pinnatim decomposita; segmentis linearibus, planis, flaccidis, non spinescentibus. Umbellae compositae, axillares, pedunculatae, in paniculam dispositae. Involucri bracteae paucae, parvae, anguste lanceolatae. Flores albi. Calycis dentes prominuli. Petala latiuscula, acumine brevi inflexo. Fructus late oblongus, a dorso compressus, subequaliter 5-alatus; alis latis, tenuibus, membranaceis. Carpella a dorso valde compressa, altero 3-alato, altero 2-alato; vittae magnae, sub valleculis solitariae vel duae. Carpophorum 2-partitum. Semen ad vittas sulcatum.

C. Dieffenbachii Cheesem. et Hemsl., *l.c.*, species unica. *Gingidium Dieffenbachii* F. Muell., Veg. Chat., 17, t. 1. *Ligusticum Dieffenbachii* Hook. f., Handb. N.Z. Fl., 729. *Angelica Dieffenbachii*, Index Kew, 1, 133. *Aciphylla Dieffenbachii* T. Kirk, Students' Fl., 211: Cheesem., Man. N.Z. Fl., 214.

Hab.—Chatham Islands: Maritime cliffs; now exceedingly scarce. *H. H. Travers! F. A. D. Cox! Captain Dorrien Smith!*

A very remarkable plant, of doubtful position. A glance at the synonyms quoted above shows that it has been placed by turns in the genera *Gingidium*, *Ligusticum*, *Angelica*, and *Aciphylla*. From the typical *Ligustica* it differs markedly in the flattened and conspicuously winged fruit, one carpel being 3-winged and the other 2-winged, or very rarely both carpels may be 3-winged. The vittae are unusually large, and are either 1 or 2 in the interspaces, with 2 or 3 on the commisural face. From *Angelica* it is separated by the equally winged fruit, in the smaller number of wings (or ribs), and in the number being unequal in the two carpels. It has much of the habit of *Aciphylla*, although the leaves and bracts are never spinescent, but differs in the flattened and winged carpels, and in the smaller number of wings (or ribs) to each carpel, to say nothing of the much larger vittae. Believing that it is best treated as a separate genus, Mr. Hemsley and myself have given it the name of *Coxella* in the forthcoming "Illustrations of the New Zealand Flora," in which a carefully prepared plate with full analytical details will appear.

The name *Coxella* is used to commemorate the services to botanical science of Mr. F. A. D. Cox, of Whangamarino, Chatham Islands. During a lengthened residence in this outlying corner of the Dominion Mr. Cox has regularly and consistently collected specimens of the flora of the islands. These he has communicated to most New Zealand botanists, accompanying them with much valuable information. It is largely through his assistance in supplying material that our present knowledge of the Chatham Islands florula is in such a satisfactory position.

In an interesting paper prepared by Captain Dorrien Smith, entitled "An Attempt to introduce *Olearia semi-dentata* into the British Islands," published in the Kew Bulletin for 1910 (pp. 120–26), which contains much information of value respecting the vegetation of the Chatham Islands, Captain Dorrien Smith gives an account of a visit to the only known locality for *Coxella*, near the south end of the main island. This is accompanied by an excellent photograph of the plant in its natural habitat.

3. **Coprosma neglecta** Cheesem. sp. nov.

Ab *C. rhamnoides* differt caule prostrato, ramulis et petiolis dense et breviter pubescentibus, foliis crassis et subcarnosis, baccis (immaturis) oblongis.

Fruticulus prostratus, divaricatim ramosus; ramulis validis dense cano-pubescentibus. Folia parva, 10–15 mm. longa, 5–12 mm. lata, oblonga vel rotundato-oblonga vel orbiculata, obtusa, petiolata, crassa et subcarnosa, marginibus recurvis, venis subtus conspicuis. Flores non visi. Bacca (immatura) parva, oblonga, 5–6 mm. longa.

Hab.—North Island: On the faces of cliffs near the North Cape; January, 1896. *T. F. C.*

A much-branched prostrate shrub 2–5 ft. long; branches wide-spreading; bark greyish-brown; branchlets stout or slender, the ultimate ones uniformly clothed with a fine greyish pubescence, which often extends up the petioles to the main veins of the leaves. Leaves very variable in shape and size, usually $\frac{1}{3}$–$\frac{1}{2}$ in. long by $\frac{1}{4}$–$\frac{1}{2}$ in. wide, oblong or oblong-spathulate to broadly oblong or orbicular, sometimes broader than long and thus transversely oblong, obtuse, usually narrowed into a rather slender petiole, but sometimes rounded or truncate at the base, thick and somewhat fleshy, margins recurved, veins reticulated, conspicuous beneath. Flowers not seen, but apparently terminating short lateral branchlets. Drupe (immature) about $\frac{1}{5}$–$\frac{1}{4}$ in. long, oblong.

As a rule, it is not advisable to describe species of *Coprosma* unless either good flowers or ripe fruit have been obtained. In this instance, however, the creeping habit, slender branchlets clothed with a fine and even greyish-white pubescence, the thick and fleshy broad obtuse leaves, and the fact that the immature fruit is oblong are characters which in combination remove it from all described species.

4. **Myosotis Laingii** Cheesem. sp. nov.

M. laetae simillima et forsitan ejus varietas, sed differt caulibus altioribus et floribus multo majoribus.

Perennis, undique pilis albidis copiose vestitus. Rami floriferi graciles, ascendentes, 30–45 cm. alti. Folia radicalia numerosa, longe graciliterque petiolata, 7–15 cm. longa, supra et infra pilis albidis obsita; folia caulina minora, superiorum sessilia. Racemi terminales, pedunculati, simplices aut rarissime furcati. Flores flavi, breviter pedicellati. Calyx elongatus, cylindraceus, lobis linearibus. Corolla anguste campanulata, 16 mm. longa, 10 mm. lata; tubus cylindraceus, fauce gibbis emarginatis instructa. Stamina 5, sub fauci affixa; filamentis elongatis; antheris majusculis, linearibus.

Hab.—South Island: Kaikoura Mountains; *J. Buchanan!* Wairau Gorge; *T. F. C.* Lake Tennyson; *R. M. Laing!* Altitudinal range from 2,500 ft. to 4,500 ft.

Perennial, everywhere clothed with copious soft white hairs. Flowering-stems several from the root, slender, decumbent below, erect above, 12–18 in. high. Radical leaves numerous, 3–6 in. long; blade about half the length, linear- or lanceolate-spathulate, obtuse or subacute, gradually narrowed into the very long and slender petiole, membranous, both surfaces clothed with soft white hairs, midrib distinct. Cauline leaves much smaller, the lower shortly petioled, the upper sessile. Racemes many-flowered, usually simple, rarely forked. Flowers large, crowded, $\frac{1}{2}$–$\frac{3}{4}$ in. long, yellow, shortly pedicelled. Calyx long and narrow, 5-partite; lobes linear, acute. Corolla narrow-campanulate; tube about half the length; throat with 5 emarginate scales; limb large, deeply lobed, the lobes oblong, obtuse. Stamens with slender elongated filaments, which are inserted just below the scales; anthers large, narrow-linear, reaching halfway up the corolla-lobes. Ripe nutlets not seen.

Many years ago the late Mr. Buchanan gave me two specimens of this plant, collected in some locality in the Kaikoura Mountains; and I have gathered what appears to be the same at the Wairoa Gorge. In the Manual I included both of them with my *M. laeta*, although they obviously differed in the much greater size of all their parts. I have now received good recent specimens, collected by Mr. R. M. Laing, and from their study have come to the conclusion that they represent a distinct species, although closely allied to *M. laeta*. I have much pleasure in associating the plant with the name of Mr. Laing, who is so well known from his long-continued researches into the *Algae* of New Zealand.

5. **Corysanthes Carsei** Cheesem. sp. nov.

Ab *C. unguiculata* R. Br. differt floribus angustioribus, labello apiculo minore, sepalo postico emarginato.

Planta perpusilla, acaulis, florifera 8–12 mm. alta. Folium solitarium, membranaceum, ovato-cordatum, acutum, 6–10 mm. longum. Flos solitarius, pro planta majusculus, horizontalis vel deflexus, supra folium subsessilis. Sepalum posticum basi angustum, tunc lato-cucullatum, apice incurvatum et emarginatum. Sepala lateralia parva, linearia. Labellum magnum, 10 mm. longum, orbiculatum, marginibus valde involutis. Columna brevis, curvata.

Hab.—North Island: Peaty swamps between Lake Tongonge and the coast, Mongonui County; *H. Carse* and *H. B. Matthews!*

A small delicate species, $\frac{1}{2}$–$\frac{2}{3}$ in. high when in flower. Leaf sessile, $\frac{1}{4}$–$\frac{1}{2}$ in. long, ovate-cordate, acute, membranous. Flower sessile or very shortly pedunculate, about $\frac{1}{2}$ in. long, horizontal or deflexed, dull-purplish Upper sepal very narrow at the base, then suddenly expanded, so that the upper two-thirds is broadly oblong and hood-shaped, extreme tip incurved and emarginate and slightly thickened and papillose. Lateral sepals placed under the lip, small, narrow-linear, 4–5 mm. long. Lateral petals still smaller, 3 mm. long. Lip large, tubular, the margins involute, meeting behind the column and enclosing it, orbicular or broader than long when spread out, extreme tip produced into a minute projecting lamina, between which and the overhanging emarginate tip of the upper sepal is the only entrance to the front of the flower. Immediately inside the entrance the surface of the lip is furnished with a broad patch of stiff papillae all pointing towards the interior of the flower, and which is continued as a narrow band down the median line of the lip. At the base of the lip the margins on each side are rolled up on themselves, thus forming two minute circular openings leading to the base of the flower. Column short, stout, curved. Capsule not seen.

This is a very curious little plant, closely allied to the Australian *C. unguiculata;* but, judging from Mr. Fitzgerald's beautiful drawing, that species has a much broader flower, the upper sepal is wider and not incurved or emarginate at the tip, the projecting lamina at the apex of the lip is much smaller, and the papillae within the lip are confined to the median line, whereas they also form a broad patch to the right and left of the median line in *C. Carsei.* There is also a relationship to *C. Matthewsii;* but, among other differences, it has a much narrower dorsal sepal, and the lip wants the projecting lamina of *C. Carsei.*

The numerous additions made to the orchid flora of the North Cape district by Mr. R. H. Matthews, and the discovery of the present species by Messrs. Carse and H. B. Matthews, shows how much might be done by careful investigation in most parts of the Dominion.

Art. XVI.—*Some Rocks of Mount Cargill, Dunedin.*

By J. A. Bartrum, M.Sc.

Communicated by Dr. Marshall.

[*Read before the Otago Institute, 3rd October, 1911.*]

In these notes an attempt will be made to describe a series of trachydolerites and phonolites outcropping near the summit of Mount Cargill, and, with them, such adjacent rocks as may be helpful in throwing light on their origin.

A difficulty in arriving at the exact relationships of the rocks in this district lies in the fact that bush and debris obscure a large portion of country where outcrops are probable.

Several references to Mount Cargill rocks have been made by different writers, notably Professors Ulrich and Park and Mr. C. A. Cotton, but Professor Marshall's paper on the "Trachydolerites" * and that on the "Geology of Dunedin"† gave the first comprehensive account of these rocks. The standard types arrived at by Professor Marshall in the latter of these two papers have been made full use of, and very much personal advice and help has been given by Professor Marshall to the writer during the preparation of this paper.

It is hoped that some of the information brought forward may help to supplement previous knowledge of the rocks described.

General Geology.

The Mount Cargill rocks form part of the volcanic complex of the Dunedin district. In several exposures the volcanic rocks overlie unconformably the Caversham sandstone, a member of the Oamaru series, which is generally referred to a Miocene age.‡ From the fact that volcanic rocks apparently have been unaffected by the earth-movements that caused disturbance of the Oamaru series, these former probably first were emitted at a period later than that of the disturbance of the Oamaru beds. The age of the earliest volcanic outburst must thus be at earliest post-Miocene.

That there are two main periods of volcanic activity in the Dunedin area is evidenced by the occurrence of a conglomerate of volcanic material overlying plant-beds that are unconformable to the Caversham sandstone.§

Professor Park considers the trachydolerites to belong to the first period.‖ To this period he assigns a Pliocene age.¶ They were extruded probably through trachytoid phonolites that have been described by Professor Marshall** and Cotton,†† and that occupy a large area on Signal Hill, about two miles south-east of Mount Cargill.

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* Trans. Aust. Ass. Adv. Sci., vol. 10, 1904, p. 186; Dunedin.
† Quart. Journ. Geol. Soc., vol. 62, 1906, p. 381.
‡ Park, "Geology of New Zealand," p. 25.
§ Marshall, "Geology of Dunedin," Quart. Journ. Geol. Soc., vol. 62, 1906, p. 390.
‖ "Geology of New Zealand," p. 148.
¶ "On Geology of North Head, Waikouaiti," Trans. N.Z. Inst., vol. 36, 1904, p. 418.
** *Loc. cit.*
†† Trans. N.Z. Inst., vol. 41, 1909, p. 111.

In describing a section exposed at the North Head, Otago Harbour, Professor Marshall, in his paper "Geology of Dunedin," shows that the phonolite was one of the earliest volcanics of the district. No definite statement as to the period during which the trachydolerite eruption took place can be made from the field evidence afforded by the outcrops of the Mount Cargill area, beyond the fact that the trachydolerites are nowhere overlaid by other lava-flows. Professor Marshall, remarking on this, and on the additional fact that no pebbles of trachydolerite are found in conglomerates formed in the interval between the two peroids of eruption, considers that the trachydolerites are amongst the latest of the Dunedin rocks.

Physiography.

Mount Cargill lies about five miles north-east of the Town of Dunedin, and forms a moderately well-rounded spur, rising to a series of sharp knobs in the Main Peak (2,232 ft.), Butter's Peaks (2,040 ft.), and Mount Holmes. There are several other less-prominent peaks at a lower elevation than these. The main spur or ridge runs south-west from the Main Peak towards Pine Hill, and on the south-east there is a gradual drop to the saddle between Mount Cargill and Signal Hill. On the north there is a steep bush-clad face leading down into the watershed of a stream draining towards Waitati. On the west flattish slopes lead out to the Leith Valley. From the south face of the Main Peak the North-east Valley Stream drains, and has cut a well-rounded valley between the Mount Cargill and Signal Hill ridges.

Occurrence of Rock Types.

From the Main Peak, looking north-east and east, three knobs are prominent. The nearest one — an abrupt rocky knoll called Butter's Peaks—is composed of a basic variety of trachydolerite and of a probable nephelinitoid phonolite dyke. The Main Peak itself, a steeply cleft ridge, running for about 10 chains in a north-east by east and south-west by west direction, is composed chiefly of the general lava trachydolerite.

A far rocky peak to the north-east—Mount Holmes, or Remarkable Rocks, by name—shows a splendid example of columnar structure in the basalt of which it is formed. A good illustration of this outcrop is given in Park's "Geology of New Zealand," p. 150. A quarter of a mile to the south-east of this basalt peak is a knob called Mount Zion, with a lofty precipitous face edging the Main North Road, and composed of a type of trachytoid phonolite called by the type-name "Logan's Point." This phonolite outcrops in a series of knolls for about a quarter to half a mile in a south-west direction from Mount Zion.

In a south-west and west direction from the Main Peak the rounded and flattish slopes stretching towards Pine Hill and the Leith Valley show, in scattered outcrops, a comparatively unvaried type of trachydolerite. On these slopes occasional rough hexagonal jointing is seen, and the disposition seems to add strength to the view of Professor Marshall that the flow of the trachydolerite was from Mount Cargill towards Mount Flagstaff.*

About a mile and a half south-west by south from the Main Peak, on the upper portion of the Pine Hill slopes, is a profusion of large blocks of rubble showing abundant large feldspathic and ferro-magnesian minerals

* "Geology of Dunedin," Quart. Journ. Geol. Soc., vol. 62, 1906, p. 407.

on the weathering surfaces. This is hypabyssal trachydolerite. Near it is also found abundant rubble of a basaltic or basanitic nature.

In a quarry on the road running from lower Pine Hill north-eastwards along the southern slopes of Mount Cargill is a type of trachytoid phonolite similar to that occupying a large area on Signal Hill, and known as the Signal Hill type. This phonolite runs south-west along the hillside from the uppermost forks of the North-east Valley Stream, just below the steep southern face of the Main Peak. Near these forks begins a winding road towards the Junction School. Along this road hypabyssal trachydolerite in large rubbly blocks is first met ; a space covered solely by basaltic debris intervenes ; and then there is an outcrop of basaltic scoria. Fragments of the so-called "Junction basalt" are found plentifully all around, and shortly the solid rock is exposed in a shallow quarry near this road.

On a knoll about 1,200 ft. high, about a quarter of a mile north-east of the scoria outcrop, a fresh basanitic rock is found in plentiful rubble. No outcrop was discovered.

Basaltic and basanitic rocks, and also a nephelinitoid phonolite, outcrop in the valley of the North-east Valley Stream, below the forks mentioned above. The last-mentioned rock is of a peculiar type, and seems to be the same nephelinitoid phonolite that occurs in the North-east Valley quarry, about a mile and a quarter down-stream from the upper outcrop.

Basaltic rubble is extensive on the hillside north-west of the North-east Valley tannery. No recognizable outcrops were found, and its relation to the Signal Hill phonolite cannot definitely be determined.

PETROLOGY.

DESCRIPTION OF ROCK TYPES.

A. Trachydolerites.

(a.) *General Lava Trachydolerite.*

In hand-specimen this is a heavy greyish-black fine-grained rock showing fairly prominent feldspar and, in places, pyroxene crystals. It breaks with a rough fracture. Feldspar and pyroxene show up prominently on weathering surfaces. This rock is described by Professor Marshall in his paper on the Dunedin trachydolerites.*

The microscope shows a base of irregular feldspar laths, with enmeshed aegirine-augite and other crystals, enclosing moderately abundant phenocrysts.

A porphyritic character is shown by the feldspar, and to a less extent by the nepheline and pyroxene.

The phenocrysts are sanidine, augite (chiefly of various brownish tints), resorbed hornblende, sodalite, nepheline, olivine, and occasionally aegirine-augite and anorthoclase.

The commonest phenocrysts are those of augite.

The sanidine shows marked corrosion, and its margins are usually dentate with aegirine-augite. Its twinning is by the Carlsbad law. The extinction in many cases is parallel to well-marked cleavage, and in some idiomorphic sections to the edge between the faces 100 and 010. The crystals are usually small, but are found up to 5 mm. by 4 mm. in size. Clear glassy crystals are characterisitic, but both liquid and aegirine-augite inclusions are common.

* Trans. Aust. Assn. Adv. Sci., vol. 10, 1904, p. 183.

A few irregular biaxial interference figures were obtained, but no sections were found suitable for definite optical tests.

Anorthoclase occurs in occasional phenocrysts, especially in the rocks from the upper Pine Hill slopes. The fine indefinite pericline and albite cross-twinning is characteristic.

Oligoclase occurs in a few crystals. It is recognized by its albite twinning, with a low extinction-angle on either side of the twinning-plane.

In one case sodalite is included in a crystal of sanidine.

The nepheline phenocrysts are large and fairly plentiful. Characteristic hexagonal cross-sections are not uncommon, but corrosion has been active as a general rule. In some sections no nepheline of the first generation appears; in others, especially in those from rocks towards Pine Hill, the mineral is comparatively coarse and plentiful.

Sodalite is plentiful. A few large sharply idiomorphic forms, simulating hexagonal cross-sections of nepheline, are present, but the characteristic sodalite crystal is irregular and flaky.

Olivine generally is a most plentiful phenocryst. The crystals are large, fresh, and rounded. A "celyphitic" structure, in which pale pinkish-brown augite and iron-ore form a "corona" around the olivine, is marked. Where the olivine has not this corona it shows typically a corrosion border of magnetite dust and a deep fringe of aegirine-augite granules.

Resorbed amphibole is a constant and characteristic phenocryst. All stages of resorption are exhibited. The cross-sections of even the wholly resorbed mineral show characteristic shape and prismatic angles. The unresorbed mineral shows intense pleochroism, in colours varying from deep brown to golden-yellow. In some sections, particularly those from rocks near the outcrop of hypabyssal trachydolerite, amphibole, next to augite, is the most abundant of the minerals of the first generation. This amphibole has been classed tentatively as barkevicite.

The occurrence of pyroxene is most commonly in glomeroporphyritic phenocrysts of a pinkish-brown variety of augite. The cleavage is characteristic. Both simple and polysynthetic twins are common. Zonal structure is noticeable.

This pyroxene was more or less unstable in the original magma, and, though of idiomorphic outline, is almost always edged by a border of aegirine-augite.

A purplish-violet pleochroic augite is found rarely in well-shaped crystals. The pleochroism is—parallel to c deep purplish-violet, and parallel to $\mathfrak{a}$ and $\mathfrak{b}$ greyish-violet.

A rare deep-green to golden-yellow pleochroic pyroxene is ascribed to aegirine or aegirine-augite. It shows good augitic cleavage on basal sections. Two or three crystals of this mineral are of large size (2 mm. by 3 mm.), and include abundant prisms of apatite and squares of magnetite. They indicate by their irregular boundary that either they themselves have been resolved, or that the aegirine-augite and magnetite are the resorption-products of an earlier mineral. The constant association of aegirine-augite and magnetite with resorbed amphibole strengthens the supposition that these two minerals are the resorption-products of the amphibole.

In one case a pale-green augite crystal includes one of olivine.

Magnetite is infrequent otherwise than as a resorption-product.

The Groundmass.

A network of predominant feldspar wraps around plentiful pale-green aegirine-augite granules, a little fine nepheline, and a little iron-ore. The feldspar, as a general rule, is in poorly shaped untwinned laths. Fluxional arrangement is rare. There is a little polysynthetically twinned plagioclase feldspar also present. The iron-ore is chiefly magnetite in small squares, but ilmenite is also present.

The nepheline is only distinguished by staining the sections. It is in minute hexagonal forms.

No cossyrite was observed in the many sections prepared of this rock, but there is an abundance of the mineral in a similar trachydolerite from Mount Flagstaff.

The granules of aegirine-augite are always irregular, and at times simulate a mossy structure. Apatite forms stout though never plentiful prisms.

Order of Crystallization.

Some of the relations are uncertain, but the probable order is (1) olivine ; (2) apatite ; (3) amphibole ; (4) augite ; (5) sodalite ; (6) sanidine, nepheline, with possibly anorthoclase and oligoclase, and then, in the groundmass, iron-ore, aegirine-augite, nepheline, and feldspar, in the order named.

Sections of a transition type of trachydolerite come from a little east of the Main Peak. Olivine, in coarse aggregates of fresh rounded crystals, with a corrosion border of magnetite dust and aegirine-augite granules, is very common. Pinkish augite has been corroded, and is edged by aegirine-augite. Large crystals of resorbed amphibole are rare, but the mineral may be represented by numerous small groups of secondary magnetic material. Feldspar sometimes encloses this magnetite. Nepheline is rare. There is a little very opaque cossyrite.

The groundmass is very dense and fine-grained ; it exhibits occasional flow structure. Feldspar continues to be more important than the aegirine-augite.

Chemical Characters.

Two analyses of the trachydolerite from two different localities are appended, and with them, for purposes of comparison, two other analyses.

	A.	B.	C.	D.
SiO_2	50·43	49·02	51·86	50·06
Al_2O_3	18·00	19·50	19·87	17·00
Fe_2O_3	3·78	4·37	6·30	2·96
FeO	5·65	6·60	3·11	5·42
MgO	2·91	2·14	2·33	3·61
CuO	5·76	6·78	3·77	8·14
K_2O	4·79	1·70	6·20	3·40
Na_2O	5·76	7·35	4·88	3·53
H_2O	1·37	1·18	1·48	4·85
Cl	0·38	Not det.	0·51	MuO 0·14
P_2O_5	Not det.	Not det.	0·36	0·66
TiO_2	Not det.	Not det.	Not det.	0·51
	98·83	98·64	100·67	100·28

A. Trachydolerite, Main Peak, Mount Cargill. (Analysis, J. Bartrum.)
B. Trachydolerite, near Pine Hill. (Analysis, J. Bartrum.)
C. Trachydolerite, Dr. P. Marshall.*
D. Shoshonite, Yellowstone National Park.†

* "Geology of Dunedin," Quart. Journ. Geol. Soc, vol. 62, 1906, p. 407.
† Rosenbvsch, "Elemente der Gesteinslehre," p. 355, No. 13, 1901 ed.

There is seen to exist a certain similarity in chemical composition between the trachydolerites and the alkali basalts. This is not borne out by the petrological and mineralogical characters, in which the trachydolerites approach closely to the phonolites of the adjoining area. The analyses, to be given later, of these phonolites show also how closely they merge into the trachydolerites in chemical characters.

(b.) *Hypabyssal Type of Trachydolerite.*

Two areas show extensive rubble of this rock—the one on Pine Hill, and the other near the headwaters of the North-east Valley Stream. It was not found actually *in situ*, but so great a heap of angular blocks as there is on Pine Hill is not likely to have travelled far.

The differences from the lava type are mainly textural, and are, indeed, few.

In hand-specimen large pyroxene, amphibole, and feldspar crystals are conspicuous. The feldspar and soda-pyroxene are porphyritic. Olivine, nepheline, and sodalite are less plentiful than in the lava type, but feldspar is more so. The corrosion of the feldspar is a noticeable feature.

The pyroxene is chiefly a pleochroic green soda-bearing variety of augite, or aegirine-augite. A little pink faintly pleochroic augite is also present. The aegirine-augite is usually idiomorphic.

Resorbed hornblende in places includes a little feldspar.

In the groundmass the aegirine-augite is less important than the feldspar, and is less mossy than in the general lava rock. The plagioclase feldspars—varying between oligoclase and acid andesine—also much increase their importance.

The main features of the type are the increased size of the phenocrysts in general and the more open nature of the groundmass.

(c.) *Dense Basic Type of Trachydolerite.*

In hand-specimen this rock is indistinguishable from the dense green nephelinitoid phonolites and tinguaites common in the Dunedin district. It has a leek-green very fine-grained matrix, in which are a few prominent crystals of feldspar and pyroxene. Many variations of a minor nature are exhibited by the rocks included in this class.

Under the microscope the distinguishing features are—(1) scarcity or lack of nepheline in the groundmass; (2) abundance of aegirine-augite and small amount of feldspar in the groundmass; (3) the dense nature of the groundmass; (4) typical scarcity of phenocrysts.

The relative importance of the different phenocryst minerals varies from section to section.

An interesting feature is the occurrence of small rounded leucite crystals with characteristic radial inclusions of aegirine-augite. Another peculiarity lies in the alteration (or, may be, corrosion) of the olivine phenocrysts. These have been more or less wholly replaced by a clear colourless secondary mineral and magnetite dust. The fibrous nature and other characters of this secondary mineral seem most characteristic of serpentine. A bluish-green chloritic mineral is sometimes connected with this alteration of the olivine.

Sharply idiomorphic, fresh olivine crystals are, however, not uncommon. There is an occasional corona of augite and magnetite to the olivine.

Phenocrysts of feldspar are less common than those of the ferromagnesian minerals; of them, sanidine is the commonest, but anorthoclase

also occurs in a few large crystals The feldspars exhibit the same rounding as in the general trachydolerite, but the edges are sharply defined.

Pyroxene and brown amphibole also form phenocrysts. The pyroxene is generally idiomorphic pale-pinkish to pale-greenish-pink augite. It is commonly fringed by dust-like aegirine-augite. Aggregates of pinkish augite are common.

In some sections nepheline forms important large well-shaped crystals. Sodalite in small flaky forms is moderately abundant. The augite includes a few apatite prisms.

The impenetrable nature of the groundmass is given it by the felted dust-like granules of aegirine-augite. Typically, no cossyrite is present; but in a few sections, where the density of the groundmass is not so marked as in typical sections, a few opaque-brown dendritic growths may be of this mineral.

A few minute feldspar needles are scattered throughout. Staining detects nepheline in the mesh of aegirine-augite dust in minute rare hexagonal and square forms.

Magnetite is very scarce, unless it occurs with aegirine-augite as a resorption-product of amphibole.

Chemical Characters.

An analysis was made of this type, and comparison with the two other analyses appended shows how closely it agrees chemically with both the trachydolerites and the trachytoid phonolites.

	A.	B.	C.
SiO_2	54·24	56·19	55·10
Al_2O_3	18·08	20·25	19·25
Fe_2O_3	2·18	2·76	2·77
FeO	3·53	2·32	1·66
MgO	0·88	1·12	0·83
CaO	5·01	4·30	5·14
K_2O	5·01	4·19	4·68
Na_2O	7·29	6·33	7·41
H_2O	1·79	0·65	2·19
Cl	0·63	..	MnO 0·32
TiO_2	..	0·57	0·48
SO_3	..	0·09	..
P_2O_5	..	0·54	0·41
	98·64	99·47	100·46

A. Basic type of trachydolerite, Butter's Peaks, Mount Cargill. (Analysis, J. Bartrum.)

B. Trachydolerite from Columbretes, Spain.*

C. Tracytoid phonolite.†

(d.) *Nephelinitoid Type of Trachydolerite.*

In hand-specimens this rock is indistinguishable from the preceding basic type.

Within a few yards in the field this type merges, in successive variations, from the general trachydolerite to true nephelinitoid phonolite.

* Rosenbusch, " Elemente der Gesteinslehre," p. 355, No. 4, 1901 ed.

† Rosenbusch, *loc. cit.*, p. 292, No. 4.

Thus field relations give no help in drawing distinctions between different petrological types, but indicate that the origin of all is differentiation of the one magma. There is, however, a possible exception to this, for an outcrop of nephelinitoid phonolite on Butter's Peaks may be a dyke.

Under the microscope the chief feature of the type is the nephelinitoid, or cellular, structure of the groundmass, due to the numerous minute hexagons of nepheline seen under moderate magnification.

The phenocrysts are typically allotriomorphic; the most common are pinkish-brown augite, sodalite, sanidine, nepheline, and olivine.

The nepheline is large and well-shaped, but is crowded with minute liquid inclusions. The crystals of sodalite are very large, and are usually crowded with minute gaseous inclusions; they show good dodecahedral cleavage.

Sanidine is clear and glassy, but exhibits shadow extinction. A few characteristic anorthoclase phenocrysts occur.

Olivine has either a dense corona of aegirine-augite with magnetite, or else a corrosion fringe of aegirine-augite and magnetite dust.

Pleochroic aegirine-augite is shown in a few well-shaped crystals that have suffered slight resorption, and have been edged by the common pinkish augite. This latter variety sometimes encloses resorbed amphibole, showing that it did not separate out till after, or was connected with, the resorption of the amphibole.

The groundmass is holocrystalline but fine-grained, and generally similar in minerals to that of the other types of trachydolerite.

Aegirine-augite in mossy granules is dominant; if often assumes a lath shape, and then shows more or less parallel alignment.

In sections of those rocks that, both petrographically and in field occurrence, approach the nephelinitoid phonolites cossyrite occurs plentifully, but is absent in other sections, unless some minute opaque dentritic growths can be referred to this mineral.

Feldspar is moderately important, and enwrapping laths show up amongst the numerous minute hexagonal forms of nepheline. Very little magnetite is present; there are a few scattered flakes of sodalite.

No analysis of this rock was made.

B. Nephelinitoid Phonolite.

As would be expected, in certain places this rock merges closely into the type of trachydolerite just described. In several sections segregations or inclusions of the basic trachydolerite previously described are very typical. They average about 7 mm. in diameter, and are most probably of the nature of segregations.

Leucite again appears as a subsidiary mineral. It is difficult to distinguish it from numerous other rounded isotropic forms that are judged from their ready gelatinization with dilute acid, and from the high percentage of chlorine in the rock, to be sodalite. The leucite is in small rounded or idiomorphic shapes, and commonly shows characteristic radial arrangement of included aegirine-augite granules.

In hand-specimen this rock is very similar to the dense basic variety of trachydolerite, but has a somewhat lighter colour and greasier appearance. It weathers very readily.

Under the microscope true phenocrysts are rarely seen, unless in the proximity of the basic inclusions, where pink augite and olivine especially are common.

The phenocrysts are of sanidine, of brownish-pink augite, of almost completely resorbed amphibole, of sodalite, and occasionally of nepheline.

Sanidine is the most common; it is usually markedly corroded, but occasional good idiomorphs show up. Carlsbad twinning is common. When nepheline occurs it is in very large crystals; sodalite is in numerous rounded and flaky forms.

Pinkish-brown augite not infrequently forms an outgrowth to resorbed hornblende. One or two deep-green pleochroic and idiomorphic aegirine-augite phenocrysts are present.

Under moderate magnification the groundmass exhibits a prominent nephelinitoid, or cellular, structure. The nepheline of these clear cellular portions is in minute hexagonal cross-sections.

Highly pleochroic aegirine-augite and cossyrite aggregates are scattered regularly and fairly plentifully in the nepheline base. All branching portions of these aggregates are in crystalline continuity, and extinguish together. The pleochroism of the cossyrite is from bright reddish-brown to brownish-black, and of the aegirine-augite from deep grass-green to greenish-yellow. The identification of the cossyrite is based on its description in this and similar rocks of the district by Professor Marshall. No forms approaching idiomorphism were found on which to apply optical tests.

In portions only of certain sections feldspar shows up well in minute needles that have rough parallelism, but elsewhere it is relatively scarce. There are a few scattered granules of magnetite.

From the east end of Butter's Peaks one section made was found to differ from the others, and to present an undoubted nephelinitoid phonolite. It probably represents an unimportant local variation of the general basic trachydolerite. Cossyrite is very scarce in this section; it is in minute dense growths. The aegirine also is very dense, and is of much less importance than in the typical nephelinitoid phonolite. Nepheline forms almost the whole of the predominant clear base of the groundmass.

Chemical Characters.

The analysis made of this Mount Cargill nephelinitoid phonolite shows a close agreement with that of the nephelinitoid phonolite represented by analysis B.

	A.	B.
SiO_2	54·88	55·01
Al_2O_3	22·80	21·67
Fe_2O_3	3·66	1·95
FeO	3·26	1·86
MgO	0·38	0·13
CaO	2·24	2·12
K_2O	3·65	3·54
Na_2O	7·53	9·78
H_2O	0·91	2·17
Cl	0·63	0·08
MnO_2	..	0·22
P_2O_5	..	0·04
	99·94	99·41

A. Nephelinitoid phonolite from Butter's Peaks, Mount Cargill. (Analysis, J. Bartrum.)

B. Nephelinitoid phonolite from Hohentwiel, Hegau.*

* Rosenbusch, "Elemente der Gesteinslehre," No. 6, p. 292, 1900 ed.

A nephelinitoid phonolite that has probably intruded earlier basanites is found in a small quarry alongside a branch track that leaves the North-east Valley to Junction School Road, and follows up the North-east Valley Stream.

The phenocrysts, which are almost entirely sanidine in Carlsbad twins and a little bright emerald-green to yellowish-green aegirine-augite, are sharply idiomorphic. The groundmass is chiefly nepheline in small hexagonal forms. Deep-green mossy aegirine-augite aggregates and flakes of sodalite are also very plentiful.

This rock is similar to, and possibly the same as, the nephelinitoid phonolite that is quarried lower down-stream in the North-east Valley quarry.

C. Trachytoid Phonolites.

No hard-and-fast line can be drawn between the nephelinitoid and some of the trachytoid phonolites of Mount Cargill. These latter phonolites present in the Mount Cargill area fall under two types, named respectively "Logan's Point" and "Signal Hill" by Professor Marshall in his paper "Geology of Dunedin," referred to previously.

The more important on Mount Cargill is the Logan's Point type, which forms Mount Zion and other knolls, and through which the Mount Holmes basalt and the trachydolerites have probably been forced. The Logan's Point is probably earlier than the Signal Hill type of trachytoid phonolite. Cotton, in a paper, "Geology of Signal Hill, Dunedin,"* brings forward evidence that supports this view.

The apparent succession of types in the Mount Cargill area will be dealt with later.

(a.) *Logan's Point Type of Trachytoid Phonolite.*

In the hand-specimen this is a dull leek-green fine-grained rock, showing a few sanidine phenocrysts. Its field outcrop shows a platy structure.

Under the microscope practically no phenocrysts appear beyond a few poorly shaped corroded ones of sanidine, and a few of pleochroic aegirine-augite and resorbed amphibole. Cossyrite and aegirine-augite, both in the allotriomorphic mossy growths common in the allied Mount Cargill rocks, are evenly and plentifully distributed in the groundmass in a clear base of nepheline and feldspar. The pleochroism of both minerals is the usual pleochroism noted already.

The feldspar of the groundmass is typically allotriomorphic, and, as well as enwrapping the aegirine-augite and cossyrite, encloses in its most intimate meshes minute nepheline crystals that often are only distinguished by staining-tests. In other sections an abundance of nepheline causes a cellular structure of the groundmass.

Occasionally the feldspar of the base shows good fluxional arrangement; the laths then prominent are polysynthetically twinned, and are referred, on their extinction-angles, to oligoclase. When the greater part of the base shows this structure the rock merges into the Signal Hill type. Similarly, where the base is highly nephelinitoid the rock verges on the nephelinitoid phonolites. This is particularly the case in sections from a small conical knob near Butter's Peaks.

In the Logan's Point rock magnetite is absent; a few prisms of apatite are included by aegirine-augite.

In a section made from an outcrop of this type near Butter's Peaks large phenocrysts of olivine and pinkish augite were found. Partial resorp-

* Trans. N.Z. Inst., vol. 41, 1909, p. 111.

tion has effected a rounding of these crystals, and an edging of aegirine-augite.

Unless these minerals have been caught up from elsewhere, their occurrence shows that a close relationship to the trachydolerites exists.

Comparison with other Logan's Point trachytoid phonolites shows that the rock from Logan's Point itself is much denser and has less mossy cossyrite and less idiomorphism of the feldspar phenocrysts. There are no feldspar phenocrysts, but abundant intensely green almost unpleochroic pyroxenes, in a trachytoid phonolite from the foot of the North-east Valley to Junction School Road.

In the same type of rock from the North Head there are conspicuous phenocrysts of sanidine, but none of aegirine-augite. The nepheline of the groundmass can only be detected by staining.

A knob on Signal Hill, above Burke's, is composed of a rock almost identical with that of Mount Cargill; few or no feldspars show up in the first generation.

Chemical Characters.

An analysis of the Logan's Point trachytoid phonolite is compared below with analyses of similar rocks.

Reference to the analyses of nephelinitoid phonolites on page 171 will show how closely the Mount Cargill Logan's Point phonolite resembles in chemical composition the nephelinitoid types.

	A.	B.	C.
SiO_2	56·12	56·8	57·00
Al_2O_3	21·32	19·7	18·56
Fe_2O_3	2·59	2·2	4·58
FeO	3·29	3·7	2·76
MgO	0·56	0·4	0·41
CaO	2·30	2·2	1·05
K_2O	4·81	7·1	6·13
Na_2O	5·79	4·3	6·34
H_2O	1·54	2·5	2·96
Cl	0·34	..	..
	98·66	98·9	99·79

A. Logan's Point trachytoid phonolite, Mount Zion, Mount Cargill, Dunedin. (Analysis by J. Bartrum.)

B. Trachytoid phonolite from East Lothian, Scotland.*

C. Trachytoid phonolite from Logan's Point.†

(b.) *Signal Hill Trachytoid Phonolite.*

This rock does not occupy any important area on Mount Cargill itself, but is extensive across the North-east Valley, on Signal Hill, and also covers a large portion of Pine Hill. Occasional sections cut from the Mount Zion phonolite show examples of this type, but these seem to be far from typical.

Basalts apparently underlie this rock towards the headwaters of the North-east Valley Stream. This agrees with the succession described by Professor Marshall at the North Otago Head.‡

* Rosenbusch, "Elemente der Gesteinslehre," p. 292, 1901 ed.

† Marshall, "Geology of Dunedin," Quart. Journ. Geol. Soc., vol. 62, Aug., 1906, p. 402.

‡ "Geology of Dunedin," Quart. Journ. Geol. Soc., vol. 61, 1906, p. 418.

Macroscopically the Signal Hill phonolite is a greasy green fine-grained rock of platy nature, showing occasional feldspar crystals.

Under the microscope there is a noticeable scarcity of phenocrysts as compared with the typical rock from Signal Hill. In the rock outcropping in the North-east Valley Stream, however, there are plentiful conspicuous amphiboles up to $1\frac{1}{4}$ in. by $\frac{1}{4}$ in. in size. Resorption of this amphibole is noticeable, and its pleochroism is marked—$\mathfrak{a}$, pale golden-yellow; $\mathfrak{b}$, rich brown; $\mathfrak{c}$, dark opaque-brown. Though the tests made were scarcely satisfactory, apparently $\mathfrak{c} \wedge \dot{c} = 6°$, A = $\dot{a}$, B = b, and mineral is positive. This amphibole is probably barkevicite, and it is considered that it is the same as that in the various other allied rocks of Mount Cargill.

Sanidine, in much corroded crystals of small size, is persistent, but never plentiful. There are occasional corroded crystals of anorthoclase, of oligoclase, and of a more basic feldspar that is apparently andesine.

The only other phenocrysts are small scarce ragged crystals of greenish and pink augite.

The groundmass is the most characteristic feature of the type.

A dense web of small feldspar laths, showing remarkable flow structure, constitutes the greatest part of the groundmass, and entangles fairly plentiful augite granules, very minute nepheline prisms, and a little scattered magnetite.

Most of the augite is the greenish soda-bearing variety, but in many sections pink augite also is common.

The chief feldspar of the groundmass is sanidine.

Cossyrite is absent.

The typical rock from Signal Hill shows in comparison with the above an abundance of resorbed amphibole and of coarse feldspars, amongst which oligoclase and anorthoclase are prominent. A little serpentinized olivine also is present.

Chemical Characters.

No chemical analysis of this rock was made.

D. Basalts.

Of three main basaltic areas to be described, the most important is the old neck of Mount Holmes. There a good example of columnar jointing is shown. The disposition of the columns is irregular, but indicates that the vent from which the basalt flowed was of the nature of a fissure. This Mount Holmes basalt has apparently burst its way through the Logan's Point phonolite outcropping on Mount Zion.

A basalt covers a considerable area near the Junction School, and is the same as that described from there by C. A. Cotton.* Mineralogically it agrees with the Mount Holmes basalt, but, as one would expect, textural differences are marked. It is very probable that this lava flowed from the former vent of Mount Holmes.

A basaltic-scoria bed of an amygdaloidal nature is found on a branch road leading north-west from the Junction School, and apparently is part or the surrounding Junction basalt.

On a knoll close to the west side of the Main North Road, about half a mile north-west of its junction with the Port Chalmers Road, is a different type of basaltic rock. It is similar in general characters to basanites found to the north-east of the district. Professor Park, in his paper on the geology of North Head, Waikouaiti,† mentions Mount Cargill as the

* "Geology of Signal Hill," Trans. N.Z. Inst., vol. 41, 1909, p. 121.
† Trans. N.Z. Inst., vol. 36, 1903, pp. 423, 424.

probable point of origin of basanitic pebbles found in gravels at Mount Cronin. It is uncertain whether this supposed basanite is that recorded by Professor Ulrich from the Mount Cargill area.

A similar rock is found in the valley of the North-east Valley Stream above where it strikes in a northerly direction away from its previous course alongside the North-east Valley Road.

After some difficulty, staining-tests made on these rocks showed a few small crystals that may be nepheline. As, however, some undoubted olivine had gelatinized and absorbed the stain, there is doubt as to this identification. For this reason these rocks are only tentatively classed as basanites.

(a.) *Mount Holmes Basalt.*

This is macroscopically an open-grained basaltic-looking greyish-black rock, showing plentiful small crystals of olivine and augite, and weathering out to a greyish-fawn colour.

Microscopically it is holocrystalline, and of porphyritic, hypidiomorphic structure. The chief phenocrysts are faint greenish-pink augite and olivine; they are of large size. The olivine is very fresh and sharply edged. Augite is frequently of a dirty-green colour; it occasionally enwraps the olivine. The augite also commonly includes magnetite, and in a few instances a little feldspar.

Feldspar and augite are both porphyritic. The feldspar typically is much corroded, and has numerous inclusions of groundmass. Twinning by the Carlsbad and albite laws is prevalent. The varieties vary from andesine-labradorite to labradorite.

The open fine-grained base which encloses the phenocrysts consists of a plexus of well-shaped feldspar laths which enwrap plentiful microlitic almost colourless augite granules, fairly abundant magnetite, a little coarser olivine, and a little ilmenite. Crystallites of indistinct nature occupy the finest interspaces between the augite granules.

Chemical Characters.

An analysis of this rock shows that it is a fairly typical basalt. The percentage of ferrous iron is particularly high, and is probably due largely to the greenish augite, as well as to the magnetite and ilmenite.

An analysis of a basalt, quoted from Rosenbusch's "Elemente der Gesteinslehre," is also appended.

	A.	B.
SiO_2	45·89	42·75
Al_2O_3	17·17	17·24
Fe_2O_3	2·60	8·01
FeO	11·77	5·88
MgO	5·80	6·17
CaO	10·05	11·14
K_2O	1·54	2·48
Na_2O	3·60	4·21
H_2O	1·20	1·06
TiO_2	..	2·13
	99·63	100·46

A. Basalt. Mount Holmes, Mount Cargill, Dunedin. (Analysis. J. Bartrum.)

B. Basalt.*

* Rosenbusch, "Elemente der Gesteinslehre," p. 323, No. 15, 1901 ed.

(b.) *Junction Basalt.*

The occurrence of this rock over an area around the Junction School has already been noted.

In hand-specimen the Junction basalt is similar to the Mount Holmes rock, but breaks with a much less regular fracture than the latter.

Under the microscope the chief difference is seen to be in the structure. The groundmass is dense and microcrystalline ; it consists of predominant magnetite in small squares, plentiful colourless augite granules, and interstitial microlitic grains of feldspar.

Large laths of feldspar showing albite twinning are fairly plentiful, and, with olivine and augite, comprise the phenocrysts. The variety of feldspar is chiefly labradorite. Olivine and augite are in large very plentiful crystals. Celyphitic arrangement of the augite about the olivine is not infrequent. The augite is a pink variety, and the olivine often shows alteration to serpentine and to carbonates.

A few large crystals of ilmenite and magnetite are present.

A curious feature of the rock is the occurrence of occasional large crystals of nepheline that have suffered considerable resorption ; there is a wide fringing zone of small feldspars and a central remnant of the nepheline. The nepheline has probably been caught up from contiguous rocks. It is comparatively plentiful in a rock found on the hillside north-west of the North-east Valley tannery—a basalt characterized by abundant feldspar and sharply idiomorphic violet augite phenocrysts, and by a very dense groundmass—and has there the same peculiarities.

The order of crystallization in the Junction basalt seems to be : Phenocrysts (in order), iron-ore, olivine, augite, feldspar, and then (in order) the magnetite, augite, and feldspar of the groundmass.

Chemical Characters.

An analysis of the Junction basalt is appended, with, for purposes of comparison, analyses of two other basalts. The analysis shows high percentages of silica, magnesia, and ferrous iron, which correspond well with the abundance of augite in the rock.

	A.	B.	C.
SiO_2	45·80	47·68	48·97
Al_2O_3	17·91	17·90	16·37
Fe_2O_3	6·14	4·48	1·33
FeO	8·69	9·05	8·56
MgO	3·92	8·71	6·22
CaO	8·10	5·65	7·49
K_2O	1·77	2·68	1·72
Na_2O	4·71	2·35	4·09
H_2O	2·10	1·16	0·38
Cl	0·11	0·20	..
TiO_2	0·35	..	3·95
P_2O_5	..	..	1·04
NiO	..	..	0·08
BaO	..	..	0·06
	99·50	99·86	100·26

A. Basalt No. 1.*

B. Junction basalt, Mount Cargill. (Analysis, J. Bartrum.)

C. Scoriaceous basaltic lava from recent eruptions at Pantellaria.†

* Cotton, " Geology of Signal Hill," Trans. N.Z. Inst., vol. 41, 1909, p. 122.

† H. S. Washington, " Titaniferous Basalts of the Western Mediterranean," Quart. Journ. Geol. Soc., vol. 63, Feb., 1907, p. 75.

Basanites.

Mention has been made already of the so-called basanites. In the hand-specimen they are fine-grained dense blackish rocks, showing few conspicuous phenocrysts.

Besides the occurrences already noted, a basanite is found as extensive rubble near the hypabyssal trachydolerite on Pine Hill.

Under the microscope these rocks show a typically dense base and a paucity of phenocrysts; augite is the commonest of the few phenocrysts that are seen. It is most often of a pale-pinkish colour, but a green augite with pink border and a purplish-violet variety are also present.

In the basanite found north of the Junction School a strongly pleochroic mica is prominent. It occurs, along with a little serpentine, as an alteration-product of the olivine; its pleochroism varies from deep brown to bright golden-brown. It is thought to be anomite.

Feldspar seldom is a phenocryst in the Mount Cargill basanites; a few very large feldspars show albite twinning, and seem to be oligoclase. They are, however, so crowded by augite granules and other inclusions that an exact determination cannot be made.

The groundmass is very dense, and is composed mainly of small grains and squares of magnetite.

In the anomite-bearing rock the magnetite is less important, and an interstitial feldspar is the chief constituent, along with grains of colourless augite. The augite is usually in fair amount in these rocks, but feldspar typically occurs only in a comparatively few needle laths.

No chemical analysis of any of the basanites was made.

Relationships of the Trachydolerite and Phonolite Series.

The analyses given in the subjoined table show how gradual a passage there is chemically from the more basic trachydolerites to the phonolites. Petrological characters also indicate that such a gradation is not a matter of chance, but represents a differentiation of many types from the one magma. In certain cases this is due to differences in the rate of cooling.

All evidence from the Mount Cargill area would show that the Logan's Point trachytoid phonolite is a portion of the main alkaline magma, and, in fact, a modification of the trachydolerites and the nephelinitoid phonolites. Evidence from other parts of the district dispels any idea of its contemporaneity with these latter rocks.

	A.	B.	C.	D.	E.
SiO_2 ..	50·43	49·02	54·24	54·88	56 12
Al_2O_3 ..	18·00	19·50	18·08	22·80	21·32
Fe_2O_3 ..	3·78	4·37	2·18	3·66	2·59
FeO ..	5·65	6·60	3·53	3·26	3·29
MgO ..	2·91	2·14	0·88	0·38	0·56
CaO ..	5·76	6·76	5·01	2·24	2·30
K_2O ..	4·79	1·70	5·09	3·65	4·81
Na_2O ..	5·76	7·35	7·29	7·53	5·79
H_2O ..	1·37	1·18	1·79	0·91	1·54
Cl	0·38	..	0·63	0·63	0·34
	98·83	98·64	98·72	99·94	98·66

A. Trachydolerite, Main Peak, Mount Cargill.
B. Trachydolerite, near Pine Hill, Mount Cargill.
C. Basic type of trachydolerite. Butter's Peaks, Mount Cargill.
D. Nephelinitoid phonolite, Butter's Peaks, Mount Cargill.
E. Logan's Point trachytoid phonolite, Mount Zion, Mount Cargill.

Source and Sequence of the Mount Cargill Rocks.

In his paper on the "Geology of Signal Hill,"* Cotton deduces that the Logan's Point phonolite is earlier than the Signal Hill type. His statement is based on evidence brought forward by Professor Marshall showing the relative sequence of the two rocks at the North Head. It is probable that the Mount Cargill and Signal Hill occurrences of the two phonolites are portions of the same flows, and, if this is the case, field evidence at Mount Cargill makes it certain that the flow of the later of the two trachytoid phonolites must have been south-west, down a steep slope of the earlier.

Basaltic rocks in the North-east Valley Stream, near its headwaters, may represent basic outpourings intermediate between the two phonolites —a supposition in accordance with the sequence noted by Professor Marshall at the North Head.†

The trachydolerite seems to overlie a surface of Signal Hill phonolite that slopes gently south-west. This, together with the fact that the Mount Holmes basalt is the north-east boundary of the trachydolerite, strongly supports the contention that the flow of this latter rock was in a south-west direction from Mount Cargill.

A series of rough joints, very steeply inclined, and running approximately east and west along the strike of the prominent rock ridge of the Main Peak and of Butter's Peaks, together with petrological evidence showing differences in the rates of cooling, tends to indicate that the eruption of trachydolerite was from a fissure occupying the site of the present ridge.

The North-east Valley seems to have begun its existence after the extrusion of the trachydolerite and before the ejection of the Mount Holmes basalt, for basalt remnants are found on both Mount Cargill and Signal Hill slopes, and a simple explanation of this is that the basalt from Mount Holmes flowed down the already formed valley.

The origin of the basanites is uncertain; possibly many of them are more of the nature of intrusions than flows, but it is probable that they are in some way connected with the basanitic outpourings that were frequent in the district north-east of the Mount Cargill area.

The nephelinitoid phonolite of Butter's Peaks may be a dyke. The other types outcropping near it are simply modifications of the main trachydolerite flow. All probably originate from the one magma.

Quantative Classification.

The quantative classification of this series of Mount Cargill rocks has been worked out by the method of Cross, Iddings, Pirsson, and Washington.‡ The following is the result:—

1. General lava trachydolerite—
   - Class II. Dosalane.
   - Order 6. Norgare.
   - Rang 3. Salemase.
   - Subrang 4 Salemose.

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* Trans. N.Z. Inst., vol. 41, 1909, p. 113.
† "Geology of Dunedin," Quart. Journ. Geol. Soc., vol. 62, 1906, p. 418.
‡ "Quantative Classification of Igneous Rocks."

2. Pine Hill lava trachydolerite—
   Class II. Dosalane.
   Order 4. Austrare.
   Rang 5. Andase.
   Subrang 4. Andose.

3. Dense basic type of trachydolerite—
   Class II. Dosalane.
   Order 6. Norgare.
   Rang 4. (Not named.)
   Subrang 4. (Not named.)

4. Nephelinitoid phonolite—
   Class II. Dosalane.
   Order 5. Germanare.
   Rang 2. Monzonase.
   Subrang 4. Akerose.

5. Logan's Point trachytoid phonolite—
   Class I. Persalane.
   Order 5. Canadare.
   Rang 2. Pulaskase.
   Subrang 4. Laurvikose.

6. Mount Holmes basalt—
   Class III. Salfemane.
   Order 6. Portugare.
   Rang 4. (Not named.)
   Subrang 3. (Not named.)

7. Junction basalt—
   Class.—Between II (Dosalane) and III (Salfemane).
   Order 5. Germanare. (Gallare.)
   Rang 3. Andase. (Camptonase.)
   Subrang 3. Shoshonose. (Kentallenose.)

Art. XVII.—*Descriptions of New Native Species of Phanerogams.*

By D. Petrie, M.A., Ph.D.

[*Read before the Auckland Institute, 28th November, 1911.*]

Colobanthus monticola sp. nov.

Planta musciformis, humillima, dense caespitosa, ramosa, glaberrima.

Folia arcte imbricata, paribus oppositis basi in vaginam membranaceam brevem connatis, 6–8 mm. longa, lineari-subulata, acicularia, viridia, marginibus stramineis valde incrassatis, cetera evenosa.

Flores laterales breviter pedunculati, pedunculis fructiferis elongatis.

Calyx alte 4-partitus; lobis anguste lineari-subulatis, acicularibus, foliis subsimilibus.

Stamina 4, inter calycis lobos disposita, lobisque dimidio breviora.

Styli 4, breves, stamina vix superantes.

Capsula 4-loculata, sepala aequans matura.

A very low densely tufted branched glabrous moss-like plant, forming small cushions rising an inch or less above the ground.

Leaves closely imbricating, spreading, opposite pairs connate at the base and forming a short membranous sheath, 6–8 mm. long, linear-subulate, acicular, green, with strongly thickened margins, otherwise veinless.

Flowers near the tips of the branchlets, lateral, shortly peduncled, the peduncles elongating in fruit.

Calyx deeply 4-partite, the lobes narrow linear-subulate, acicular, and leaf-like.

Stamens 4, short, inserted between the calyx-lobes and barely half as long.

Styles 4, short, barely exceeding the stamens.

Capsule 4-celled, as long as the sepals when mature.

Hab.—Rocky faces of the Sealey Range, Mount Cook district, at 5,500 ft.

The present species is closely allied to *C. canaliculatus* T. Kirk. It differs in the number of sepals and stamens, which are uniformly 4; in having the stamens and styles much shorter than the sepals; and in the form of the calyx-lobes, which are linear-subulate and acicular.

Epilobium microphyllum A. Rich. var. prostratum var. nov.

Planta typo simillima, ramis omnibus prostratis diffusisque, pedunculis floriferis longioribus.

Plant similar to the type, except in its prostrate diffuse branches and longer floriferous peduncles.

Hab.—Broken River (lower part); Opihi River (near Fairlie); vicinity of Naseby, D. P.; Mount Somers, B. C. Aston.

This curious form maintains its distinctive characteristics over a wide area of the South Island. It occurs on gravelly flats in valley-bottoms.

Aciphylla intermedia sp. nov.

Caulis erectus, 4–6 dcm. altus.

Folia parum rigida, 2–3-pinnata, 25–40 cm. longa; vagina una cum petiolo laminam dissectam aequante vel excedente; foliola ultima brevia (8–12 cm. longitudine), angusta (4–5 mm. latitudine).

Inflorescentia late oblonga, ± 30 cm. longa.

Bractearum vaginae anguste obcuneatae, in prolongationem 1–2-pinnate divisam foliorum laminis subsimilem productae.

Pedunculi universales congesti, longiusculi, tenues, sulcati.

Fructus lineari-oblongus, utraque facie 5-alatus.

Culms erect, 4–6 dcm. high, rather stout (2½ cm. across in the lower part), strongly grooved.

Radical leaves numerous, 25–40 cm. long, 2–3-pinnate, pinnae in 4 or 5 pairs; ultimate leaflets crowded, narrow-linear, grooved, slightly rigid, 8–12 cm. long, 4–5 mm. broad, spinous at the tips, the margins thickened and delicately erose.

Sheaths and petioles together equalling or exceeding the dissected blades; sheaths 8–10 cm. long, 1 cm. broad at the tops, narrow-obcuneate, furnished at either side with a linear spinous leaflet occasionally subdivided and barely half as long as the petiole.

CORRIGENDA.

Page 180, line 30.

As the specific name *intermedia* is already appropriated, if the genus *Ligusticum* as used in Cheeseman's Manual be merged with *Aciphylla*, the name *oreophila* is suggested by the author for the species.—EDITOR.

[*Face p. 180.*

Inflorescence broadly oblong, 30 cm. long or less; bracts numerous, crowded, with rather long thin flaccid narrow-obcuneate sheaths, surmounted by two short linear lateral spines and continued into a 1–2-pinnate leaf-like prolongation greatly exceeding the sheath and bearing 2–3 pairs of leaflets besides the terminal one.

Principal peduncles of the branched umbel crowded, slender, grooved, about as long as the bracts.

Fruit linear-oblong, 5-winged on either face.

Hab.—Mounts Hector and Holdsworth, Tararua Range, Wellington; on the alpine meadow, from 3,500 ft. upwards.

I am indebted to Mr. B. C. Aston for specimens of this species, which is intermediate between *A. Colensoi* Hook. f. and *A. Monroi* Hook. f., with closer affinity with the latter. It is the plant referred to under the name *Aciphylla Monroi* Hook. f. in my list of the plants observed on Mount Hector (Transactions, vol. 40), and probably also the plant so named in Mr. Aston's list of the plants of the Wellington district (Transactions, vol. 42). The longer more flaccid leaves, the stout tall stem, and especially the dense broad elongated inflorescence mark it off from *A. Monroi*. The male inflorescence has not so far been seen. The plant is of infrequent occurrence on the Tararuas, where, however, *A. Colensoi* is most abundant.

Coprosma Astoni sp. nov.

Frutex subhumilis, gracilis, ramosus, ± 2 m. altus.

Rami divaricantes, graciles, foliosi; cortice ± rugoso, cinereo-incano; ramulis dense breviterque incano-pubescentibus.

Folia plerumque fasciculata, anguste linearia, 6–10 mm. longa, 1½ mm. lata, leviter retusa vel truncata, tenuia, glaberrima, plana, basim versus subattenuata, supra enervia, in siccitate leviter recurva.

Flores sessiles, ramulos laterales valde abbreviatos terminantes; masculi solitarii vel 2–4-fasciculati; feminei solitarii.

Drupae globosae, magnitudine mediocres, clare rubrae.

A rather low slender branched shrub, 2 m. high, or less.

Branches divaricating more or less, slender, leafy; bark dull grey, more or less rough and wrinkled; branchlets brownish-grey, closely clothed with short stiff greyish pubescence.

Leaves in small fascicles on the arrested side shoots, on the youngest twigs often in opposite pairs, narrow-linear, 6–10 mm. long, 1½ mm. broad, truncate or retuse, narrowed towards the base, thin, flat, glabrous, slightly recurved when dry, nerveless above, below with evident midrib and indistinct nerves.

Stipules grey, bluntly triangular, long-ciliate.

Male flowers terminating the short side shoots, sessile, solitary or in fascicles of 2–4; female similarly placed, solitary.

Drupes globose, rather small, bright red.

Hab.—Whisky Gully, near Tapanui, B. C. Aston and L. Cockayne; the Hump, between Lake Hauroko and the sea, J. Crosby Smith; Routeburn Valley, in shady beech forest, D. P.

The present species has its nearest ally in my *Coprosma Banksii;* its leaves are smaller and shorter, very uniform in size and shape, and more freely fascicled; the branchlets are uniformly grey-pubescent; and the drupes are smaller, globose, and bright red. It is a very distinct plant, and the leaves are quite characteristic.

Celmisia Cockayniana sp. nov.

Folia anguste obovato-spathulata, 5–10 cm. longa, 1½–2 cm. lata, subacuta, subcoriacea, minute denticulata (denticulis subteretibus), minute apiculata; superne glabra, distincte venosa; subtus dense et appresse albo-tomentosa (costa media excepta), venis haud distinctis.

Scapi 2–3, 1½–2 dcm. longi, subgraciles, pilis articulatis glandulosis (ut etiam bracteae involucrique squamae) viscosi, raro apice divisi; bracteae numerosae, ± imbricatae, lanceolato-oblongae, acutae vel subacutae.

Involucri squamae pluri-seriatae, lineari-subulatae; interiores longiores angustioresque, apicibus sparse lanatae.

Capitula magnitudine mediocria, ± 12 mm. lata.

Achaenia linearia, hispido-sericea.

Leaves rather few, narrow obovate-spathulate, 5–10 cm. long, 1½–2 cm. broad, subacute, rather coriaceous, distantly and minutely denticulate, the short semiterete teeth standing out from the margin, bluntly apiculate; upper surface dull green (when dry), glabrous, with evident venation; under-surface densely clothed with closely appressed whitish tomentum, except the midrib, veins indistinct.

Scapes 2–3 on each short creeping shoot, 1½–2 dcm. high, viscid, densely clothed, as are the bracts and involucral scales, with glandular jointed hairs, rarely branched at the top; bracts numerous, overlapping, lanceolate or lanceolate-oblong, acute or subacute.

Involucral bracts numerous, in several series; the inner longer, narrower, and sparingly cottony above.

Heads of moderate size (about 12 mm. across).

Achenes linear, hispidly silky.

Hab.—Mount Fyffe, Seaward Kaikouras, at 4,000 ft.

For specimens of this species I am indebted to Dr. L. Cockayne, who collected them so long ago as 1892. I have put off describing them, in the hope that further material might be procured, but the plant has not been met with since. Its affinity is with *C. hieracifolia* Hook. f. In form the leaves recall those of some states of *C. Sinclairii* Hook. f., but they are more coriaceous and much less distinctly dentate. The abundant glandular pubescence of the scape and its members relates it more clearly to *C. hieracifolia*, from which it differs in the whitish tomentum and in the smaller narrower spathulate more acute leaves.

Celmisia Boweana sp. nov.

Folia parum numerosa, stricta, integerrima, vix coriacea, 14–22 cm. longa, 1–1¼ cm. lata, anguste lineari-lanceolata, ad apicem versus gradatim attenuata, acuta, marginibus ± recurvis; superne glabra vel glabrescentia, per totam longitudinem rugato-sulcata, flavido-viridia; subtus ± sulcata, pilis flavidis laxe appressis (costa media excepta) tomentosa; apicibus nonnunquam laxe lanatis.

Vaginae ± 6 cm. longae, striatae, membranaceae, extra incano-tomentosae, intus plerumque glabrae.

Scapi 1–4, tenuiores, foliis subduplo longiores, pilis subflavidis laxe tomentosi; bracteae numerosae, lineares, ad apicem versus diminuentes, tomentosae.

Capitulum ± 2½ cm. latum; involucri squamae lineares, tenues, tomentosae.

Achaenia glabra vel parum hispidula.

Leaves 14–22 cm. long, 1–1¼ cm. broad, fairly numerous, strict, narrow linear-lanceolate, entire, slightly coriaceous, gradually tapering to the acute tip, marked by close parallel longitudinal grooves or fine wrinklings above and less prominently below; upper surface yellowish-green, glabrous or glabrescent, the tips sometimes loosely tomentose on both surfaces; under-surface, except the midrib, covered with loosely appressed pale-yellow cottony tomentum; margins more or less recurved; sheaths about 6 cm. long, thin and membranous, glabrous on the inside, cottony-tomentose on the edges and outside.

Scapes 1–4, rather slender, flexuous, slightly rigid, nearly twice as long as the leaves, densely clothed with creamy-yellow loose cottony tomentum; bracts numerous, linear, thin, tomentose except on the midribs, gradually diminishing towards the top.

Heads about 2½ cm. across; involucral bracts numerous, linear, thin, cottony.

Achenes glabrous or slightly hispidulous.

Hab.—Sealey Range, Mount Cook district, in tussock meadow, about 5,000 ft.; T. F. Cheeseman, Mrs. F. Bowe, and D. P.

This species is dedicated to Mrs. F. Bowe, a keen observer and ardent lover of our native alpine and subalpine plants, who first directed my attention to it. Mr. T. F. Cheeseman, F.L.S., collected it a good many years ago, and he considers it a form of *C. Monroi* Hook. f. This view I am unable to entertain. It differs from *C. Monroi* in the narrower, less coriaceous, more acute leaves that are green above and very distinctly grooved or finely wrinkled; in the yellowish loosely appressed tomentum that clothes the under-surface of the leaves and the scapes; and in the more slender flexuous scapes.

Gentiana Matthewsii sp. nov.

Planta subgracilis, ramosa, glaberrima, annua (?), 1½–2½ dcm. alta.

Caulis a basi ramosus; rami graciles, adscendentes vel suberecti, subquadrangulares.

Folia radicalia pauca, subrosulata, spathulata, tenuia, 2–4 cm. longa, ± 6 mm. lata, obtusa vel subacuta; caulina sessilia, late ovata vel ovato-triangularia, subacuta, basi semi-amplexicaulia, 8–12 mm. longa, in paribus distantibus disposita.

Flores subnumerosi, solitarii, albi, 10–15 cm. longi, ramulos ultimos terminantes.

Calycis lobi ovato-oblongi, subacuti, corolla persistente fere dimidio breviores.

Capsula matura breviter rostrata, corollam superans.

A rather slender branched glabrous annual (?) herb, 1½–2½ dcm. high.

Stems branched from the base and again more or less subdivided; branches slender, ascending or suberect, more or less distinctly quadrangular from ridges running down from the bases of the cauline leaves.

Radical leaves few, subrosulate, thin, spathulate, 2–4 cm. long, about 6 mm. broad, obtuse or subacute; cauline 8–12 mm. long, sessile in distant pairs, broadly ovate or ovate-triangular, subacute, semi-amplexicaul.

Flowers fairly numerous, solitary, at the tips of the ultimate branchlets, 10–15 mm. long, white.

Calyx divided for three-quarters its length, half as long as the corolla; the lobes ovate-oblong, subacute.

Stamens rather longer than the calyx-lobes. Capsule when mature one-quarter longer than the persistent nearly closed corolla.

Hab.—Moist grassy slopes near Lake Harris, Routeburn Valley, Lake Wakatipu, 4,000 ft.

This species is somewhat closely allied to *G. Grisebachii* Hook. f., differing in the stouter more erect stems and branches, the much larger flowers, and the shorter broader calyx-lobes. It is named in honour of the late Henry J. Matthews, for some years Chief Forester under the Dominion Government. Though Mr. Matthews did not write much on botanical subjects, he had a wide and accurate knowledge of the native flora, and, as he was an acute observer and had occasion to visit many out-of-the-way districts, he formed a fine collection of the native plants, and contributed very considerably to our knowledge of plant-distribution and to the elucidation of several imperfectly known species, besides discovering a number of new ones. To his kindness I am indebted for numbers of interesting and valuable specimens that have greatly enriched my herbarium. He was equally liberal to other botanical workers. His premature death was a great loss to the science he loved so well. The magnificent alpine garden that he established at his home in Dunedin was one of the sights of the Dominion. Many of its treasures are still in cultivation in the Dunedin Botanical Gardens, which the taste and talent of Mr. Tannock have made so attractive and instructive.

Euphrasia Laingii sp. nov.

Planta perennis, erecta vel basi decumbens, 1–2 dcm. alta, a basi tantum ramosa, bifariam pubescens.

Folia in paribus distantibus disposita, erecta, cuneata, 8–10 mm. longa, 4–6 mm. lata, sessilia, glaberrima, subcoriacea, obtusa, apice triloba (lobo medio lato, lateralibus angustis), subrecurva.

Inflorescentia racemus spiciformis, elongata (5–10 cm. longa), multibracteata, bracteis foliis similibus.

Flores axillares plerumque in paribus oppositis dispositi, pedicellati, pedicellis folia aequantibus et ± bifariam pubescentibus.

Calyx bracteis aequilongus, breviter 4-lobatus, lobis acutis vel subacutis, manifeste venosus, venis ad 10.

Corolla infundibuliformis, 12–15 mm. longa, limbo valde dilatato, venis manifestis.

Capsula cuneato-oblonga, bracteis aequilonga, calycis tubum vix vel omnino aequans.

Perennial, erect or decumbent at the base, 1–2 dcm. high, branched from the base, strongly bifariously pubescent.

Leaves in rather distant pairs, erect, cuneate, 8–10 mm. long, 4–6 mm. broad at the tops, sessile, glabrous, subcoriaceous, the wide obtuse tips cut into a broad median lobe and 2 narrow lateral ones, slightly recurved, dull dark green.

Inflorescence a bracteate spike-like raceme, 5–10 cm. long, bracts leaf-like.

Flowers generally in opposite pairs, pedicellate, the pedicels as long as the leaves and more or less bifariously pubescent.

Calyx as long as the bracts, 4-lobed, the lobes a quarter the length of the tubular part, acute or subacute, veined, the 5 veins corresponding to the midribs more prominent than the others.

Corolla-tube funnel-shaped, much exceeding the calyx, 12–15 mm. long, limb widely expanded with evident nerves; lower lip 3-lobed emarginate, upper 2-lobed retuse.

Capsule cuneate-oblong, equalling the calyx-tube or rather shorter. Seeds numerous in each cell (8–10).

Hab.—Mount Peel and Mount Winterslow, R. M. Laing; Craigie Burn Mountains, at sources of Broken River, L. Cockayne and D. P.; Hooker River, Mount Cook district, T. F. Cheeseman and D. P.

This species is intermediate between *E. Monroi* Hook. f. and *E. revoluta* Hook. f. The pedicellate large flowers are like those of the latter, while the erect stems, the subcoriaceous leaves, and the capsule resemble those of the former. The elongated inflorescence, the pedicellate large flowers, the erect habit, and the characteristic cuneate leaves unequally 3-lobed at the tips, form its most distinctive characters. The plant may be easily identified by the leaves alone.

Euphrasia Townsoni sp. nov.

Annua; culmi graciles, erecti, simplices vel a basi ramosi, 4–7 cm. alti, pilis albis crispatis in parte articulatis et glanduliferis pubescentes.

Folia pauca, parva, in paribus remotis disposita, sessilia, glaberrima, anguste rhomboidalia, dente unico prominente a utroque latere prope medium et lobo terminali acuto triangulari instructa, 6 mm. longa, 2 mm. lata; marginibus reflexis.

Flores pauci extremum culmum versus et saepe in paribus oppositis dispositi, majusculi, pedunculati; pedunculi quam folia ter quaterve longiores, gracillimi, pubescentes; in siccitate subflavido-albi.

Calyx campanulatus ad tertiam partem 4-lobatus, lobis acutis, angustis.

Corollae tubus calycem paullo excedens, limbus late expansus; labium superius 2-lobatum, inferius alte 3-lobatum, lobis omnibus emarginatis; venis conspicuis.

Capsula calyce brevior; semina numerosa.

Annual; stems slender, erect, simple or branched from the base, 4–7 cm. high, pubescent (in part bifariously) with short crisped white hairs intermixed towards the tops with jointed glandular ones.

Leaves few, small, in remote opposite pairs, sessile, narrow-rhomboidal, with a single prominent acute tooth on either side about the middle and an acute triangular terminal lobe, glabrous, subcoriaceous, margins reflexed, 6 mm. long, 2 mm. broad.

Flowers few towards the tips, often in opposite pairs, pedunculate, large, yellowish-white when dried; peduncles 3 or 4 times as long as the leaves, very slender, pubescent.

Calyx campanulate, 4-lobed one-third the way down, acute, narrow.

Corolla-tube a little longer than the calyx; limb wide-spreading; upper lip 2-lobed, lower deeply 3-lobed, all the lobes widely emarginate; veins distinct.

Capsule shorter than the calyx; seeds numerous in each cell (8 to 10).

Hab.—Mount Rochfort, near Westport, W. Townson; Denniston, J. Caffin (1896).

The leaves of this species are highly characteristic, and easily distinguish it from any of the other native species. The long slender straight peduncles also form a good distinctive character. It gives me pleasure to name the species after Mr. W. Townson, who has so successfully explored the floral riches of the West Nelson district, and to whom I am indebted for specimens of a number of the species peculiar to that part of the South Island.

Pimelea Crosby-Smithiana sp. nov.

Planta humilis, ramosa, glabra.

Rami subgraciles, cicatricibus foliorum delapsorum notati.

Ramuli glaberrimi, subquadrangulares.

Folia dense quadrifariam imbricata, erecto-patentia, glaberrima, acuta, supra concava, infra distincte carinata, ad basim sessilem attenuata, anguste ovata, 7 mm. longa, 3 mm. lata, consimilia, margine cartilagineo instructa; subfloralia similia sed paullo latiora.

Inflorescentia capitata, floribus numerosis.

Perianthii tubus foliis aequilongus, passim lanis longis albis vestitus; lobi late oblongi, obtusi, ciliati.

Stigma exsertum.

A low diffusely branched shrubby plant.

Branches rather slender, greyish-brown, marked by the scars of fallen leaves.

Branchlets glabrous, subquadrangular.

Leaves closely quadrifariously imbricating, erecto-patent, glabrous, acute, concave above, strongly keeled below, narrowed at the sessile base, narrow-ovate, 7 mm. long, 3 mm. broad, very uniform, with a cartilaginous margin all round; subfloral similar to the cauline but slightly broader.

Inflorescence of numerous flowers, capitate.

Tube of perianth as long as the leaves, everywhere clothed with long white hairs; lobes broadly oblong, obtuse, ciliate.

Stigma exserted.

Hab.—The Hump, a high hill between Lake Hauroko and the sea.

This plant was collected by Mr. J. Crosby Smith, F.L.S., of Invercargill. Its nearest relative is *P. Gnidia* Willd. The south-west corner of the South Island is difficult to explore, but Mr. Crosby Smith is reaping a fine reward for his zeal in examining this virgin country.

Festuca multinodis Petrie and Hackel sp. nov.

Culmi caespitosi, decumbentes, tandem ascendentes, ramosi, foliosi, 1–3 dcm. longi.

Folia in culmis singulis ad 12, ± secunda.

Panicula 3–6 cm. longa, ovata vel lanceolata, ± complanata; rami inferiores binati, rhachi ramisque glabris.

Glumae floriferae plerumque ex-aristatae.

Densely tufted; culms decumbent below, finally ascending, leafy, more or less geniculate, 1–3 dcm. long, slender, terete, subrigid. Innovation shoots extra-vaginal.

Leaves generally secund, as many as 12 on each culm; sheaths long, overlapping, glabrous, obscurely striate; blades abruptly contracted above the ligule, with a callus at their point of origin, shorter than the culms, involute, setaceous, glabrous, acute, not or barely striate.

Panicle 3–6 cm. long, ovate or lanceolate, more or less flattened, straight, compact; rhachis and branches glabrous; lower branches in twos, short, sparingly subdivided.

Spikelets subsessile or shortly pedicellate, narrow-lanceolate, 8–12 mm. long, bearing 4–8 rather distant florets.

Empty glumes unequal, thin, the upper reaching to the tip of the lowermost floret, narrow-lanceolate, acute, the lower 1- the upper 3-nerved.

Flowering-glumes coriaceous, lanceolate, acute; awn none, or very short; nerves 5, very obscure. Palea as long as the flowering-glume, slightly coriaceous, 2-nerved; nerves glabrous.

Hab.—Coastal cliffs and rocky slopes at Port Nicholson, and the shores of Cook Strait.

Mr. B. C. Aston has furnished me with a fine series of specimens of this grass, which gives promise of some considerable economic value. It yields a large bulk of delicate foliage, and deserves experimental cultivation.

Professor Hackel, who has kindly reported on specimens forwarded to him, and has also suggested the specific name, writes me as follows: "The species differs from *Festuca rubra* L. not only in the number of nodes and leaves, but also in the character of the innovation shoots, which are extravaginal throughout, while in *F. rubra* part of them grow up in the axils of the persistent sheaths; the sheaths of *F. rubra* are closed up to the mouth, those of *F. multinodis* are split throughout. The inflorescence and the spikelets show little difference, but the pales of *F. multinodis* are quite smooth on the keels, while these keels are scabrid or somewhat ciliate in *F. rubra*."

Mr. Aston has for some years urged in correspondence with me that this *Festuca* was a new species, but, though agreeing with him, the genus is one of such difficulty that I should not have published it had not Professor Hackel supported our opinion.

Trisetum antarcticum Trinius, subspecies **tenella**, subsp. nov.

Folia fere omnia radicalia, brevia, 2–4 cm. longa, involuta, setacea, tenuiter pubescentia.

Culmi valde graciles, teretes, glabri, tenuiter striati.

Panicula spiciformis, densa, oblonga, 1½–3 cm. longa.

Spiculae sessiles, compressae, 4 mm. longae.

Glumae vacuae subaequales; floriferae vacuis paullo longiores: arista glumam aequans.

A slender erect perennial, forming diminutive tufts.

Leaves 2–4 cm. long, involute, setaceous, finely pubescent, one-third as long as the culms or less; ligule short, truncate, hyaline, erose, and more or less ciliate. Cauline leaves solitary or rarely two, with sheaths several times longer than the blades.

Culms very slender, terete, glabrous, finely striate.

Panicle spiciform, dense, oblong, 1½–3 cm. long, 5 mm. broad.

Spikelets sessile, compressed, 4 mm. long, the terminal ones very shortly stalked.

Empty glumes almost equal, acute or acuminate, the lower narrower.

Flowering-glumes glabrous, a little longer than the empty; the awn springing from the back a little below the tip, about as long as the glume, slightly reflexed.

Palea as long as the flowering-glume.

Hab.—Dry shingly flats in the wide alluvial valleys of the Mount Cook district, 2,500–3,500 ft.; abundant.

The present subspecies differs from the type form of the species in the short involute setaceous leaves, the slender erect culms that greatly exceed the cauline leaves, the dense oblong spiciform panicle, and the small spikelets with nearly equal empty glumes and shorter less reflexed awns. Its distinctive characters show little variation. Its foliage is so short and scanty that it is a quite unimportant element in the valley pastures.

Art. XVIII.—*On* Danthonia nuda *Hook. f. and* Triodia Thomsoni *(Buchanan) Petrie, comb. nov.*

By D. Petrie, M.A., Ph.D.

[*Read before the Auckland Institute, 28th November, 1911.*]

In my herbarium there is a good specimen of *Danthonia nuda* Hook. f., collected at a high elevation on the Ruahine Range, Hawke's Bay. There can be little doubt that this plant is a true *Danthonia,* though it makes some approach to the genus *Triodia.* Sir J. D. Hooker's description of it is brief, and wanting in some important details. The culms are very slender, leafy, and but little longer than the leaves. The sheath of the topmost cauline leaf is three or four times as long as the blade, which reaches to the base of the panicle. The flowering-glumes show considerable variation in the hairy covering, which is more ample than one would suppose from Hooker's description. Besides the one or two small tufts of hairs on the sides of these glumes, there is usually a scanty band of sparse hairs across the back just above the middle, and often also a few straggling hairs lower down but above the basal tuft. The awn, which is quite straight, is one-third as long as the glume. The florets in each spikelet are more commonly 2 than 3.

I have a few indifferent pieces of what is most likely this species from the Tararua Range, collected by that excellent observer Mr. B. C. Aston. Unfortunately, they are all past flower.

Danthonia nuda has long been confounded, and by myself in the first instance, with a somewhat similar grass, the *Danthonia Thomsoni* of Buchanan. The latter was discovered by me at Mount St. Bathan's, Central Otago. As it has a wide distribution in districts explored by Hector and Buchanan, and also by Von Haast, it is singular that it was not found before. It may have spread and increased since these early explorations were made, but I consider it much more likely that it was merely overlooked or mistaken for some other species that was collected then. At present it has a wide distribution in the upland districts of South Canterbury, Otago, and Southland. It is fully and accurately described in Mr. Cheeseman's Manual under the name *Danthonia nuda* Hook. f., though he notes that his plant may not be the same as Hooker's. The grass is not, however, a *Danthonia,* but a characteristic species of *Triodia,* to which I now give the name *Triodia Thomsoni.* It was originally named in compliment to Mr. G. M. Thomson, and I am specially pleased to be able to associate permanently with it the name of this old and valued friend. As a pasture-grass *Triodia Thomsoni* possesses a high value. It has a fair amount of foliage, is deeply rooted so as to withstand drought and exposure to drying winds, and is palatable and highly nutritious. It forms one of the most common and useful of the bottom grasses of the tussock-steppe in all the upland districts through which it ranges, and is much eaten by sheep. It is well worth artificial cultivation, and promises to help in reclaiming the now desert and semi-desert lands from which the native pasture has disappeared through long-continued overstocking.

Triodia Thomsoni differs from *Danthonia nuda* in the narrow panicle with erect branches, the longer less-leafy culms that greatly exceed the leaves, the longer narrower more numerous spikelets that usually contain 5–7 nearly glabrous florets, and the much shorter less rigid awns.

Art. XIX.—*The Migrations of the Polynesians according to the Evidence of their Language.*

By Professor J. Macmillan Brown.

[*Read before the Wellington Philosophical Society, 6th September, 1911.*]

In the "Transactions of the Royal Scientific Society of Gottingen" for 1909 there appears a long paper on this subject by the late Professor Finck, of Berlin. It attempts, as its title implies, to point out some of the distinctions between the various languages of Polynesia, and by this means to indicate the lines of migration that peopled the islands in which they are spoken.

The gist of the arguments and conclusions is given in the last two pages, and is somewhat as follows: From the southern Solomons a really united people shifted to the northern fringe of Polynesia on their eastward trek. Before the expedition turned southwards to Samoa the ancestry of the present-day Ellice and Tokelau people branched off. The speech of that time possessed all that marks Polynesian as contrasted with the related Melanesian, especially the use of the old trial as plural, and the employment of separate possessive pronouns where once only a suffix was used; it was, in fact, probably the fundamental Polynesian tongue. The use of *afe* for "a thousand" does not contradict this, although it appears in this sense only in Fakaofa, Futuna, Samoa, Tonga, Uvea, and Niue; for the word is, as the Maori *awhe* shows, common to Polynesia; but it was extruded in the other dialects by *mano*. There was a long rest in Samoa, as is shown by the use of *tokelau* for "north" and *tonga* for "south" in a majority of the groups, words taking this sense from the direction of the Tokelau and the Tonga Groups from Samoa. After a small colony had swarmed off westwards to Futuna, the great eastward-going expedition went southwards to the Tonga Archipelago, as is shown by the use of *h* in all the groups to the south and east for *s* in Samoa and its immediate neighbours, and by the use of *toko* as a personal prefix to words implying number and quantity in all to the south and east for *toka* of Samoa, Fakaofa (the Tokelau Group), Vaitupu (Ellice Group), and Futuna. After a short rest in Tonga the expedition went off eastwards, leaving a contingent which sent branches to Niue and Uvea. In the Cook Group it made a long sojourn, and there formed the ground speech of eastern Polynesia; it changed *l* into *r* and *f* into *h* before *o* and *u*, brought the adnominal particles *na* and *no* into use beside the older *a* and *o*, and abbreviated the old possessive *tou* into *to*.

From this point various expeditions set out. One went to New Zealand and the Chatham Islands and developed *h* for *f* before other vowels than *a* and *o*; it left before the counting by pairs arose that characterizes the other eastern Polynesian dialects. A second went off south-east to Mangareva; thence a branch hived off to Easter Island, farther in the same direction, before the birth of the linguistic neologisms that unite the dialects of the Marquesas and Hawaiian Groups with that of Mangareva, the formation of adverbs by prefixing *ma* or *mo* to a noun, and the change of *tokerau* into *tokorau*. It was long before this northern expedition set out—long enough to develop these peculiarities. The Marquesas Group developed as linguistic characteristics the pronominal form *toia* and the further duplication of numeration by pairs in the case of *rau* (there equal to 400) and *mano* (there equal to 4,000) before sending off the Hawaiian branch. Meantime from the Cook Group another colony hived off to Tahiti, whose

dialect seems to be closely akin to that of Rarotonga, as is shown by the common use of the plural and dual prefix *pu'e*. From Tahiti the Paumotu and Manahiki Groups were colonized.

At the end of the article a sketch-map is given of these branching migrations. But the limitations of the linguistic method are revealed by the accompanying sketch-maps, one made by Horatio Hale in the "forties" of last century on the "Wilkes Expedition," another by Gerland for Waitz's "Anthropologie" in the "sixties," and a third by Weule for Helmolt's "History of the World" early this century. Hale brings the expedition first to Samoa, with offshoots to the Ellice and Tokelau Groups, then to Tonga, and thence direct to New Zealand and the Chatham Islands; from Samoa, also, one goes off to Tahiti, whence one goes to the south-east Marquesas, a second to the Tubuai Archipelago, and a third to the Cook Group. A third colonizing expedition leaves Samoa for the Cook Group, the Tubuai Archipelago, and Mangareva. Besides the branch to New Zealand, Tonga sent off one to the north-west Marquesas and on to Hawaii. Gerland, like Finck, brings his primary expedition through the Ellice and Tokelau Groups to Samoa, thence, like Hale, over Tonga to New Zealand and the Chatham Islands, whilst, as in Finck's, a Samoan offshoot goes to Futuna and one Tongan offshoot to Uvea and another to Niue. He also sends a main expedition, like Finck, over the Cook Group to the Tubuai Archipelago, and one to the Marquesas, a third to Easter Island, and a fourth to Hawaii. Weule, like Hale, brings his expedition first to Samoa; thence one colony goes direct to Hawaii and another by way of Tahiti; a third goes direct to the Cook Group, and thence to the Tubuai Archipelago and Mangareva. From the Cook Group a colony goes to New Zealand, whilst from Tahiti one goes to the Cook Group and another to the south-east Marquesas, and the north-west Marquesas are peopled from Tonga.

There is no better criticism of the linguistic method of finding lines of migration than the presentation of these differences. The fact of the matter is that these pure philologists isolate a few small phenomena that each belongs to several groups, and ignore hundreds of others in which the groups thus united disagree. One instance will be enough: Finck gives a table of the sounds of each group, and then he proceeds in his sketch to ignore some of the more striking variations. He gives *ts* (the English missionaries make it *ch*) as a variation of *t* in Futuna, Uvea, Tonga, and the Chatham Islands before the vowel *i;* all the other dialects have only *t;* yet he brings no migration from any one of these direct to the Chatham Islands, skipping New Zealand. So *wh* is given as a variation of *h* and *f* not only in New Zealand and the Chatham Islands, but in the Tokelau Group; and the same groups are united by using *w* for *v*. Yet he ignores this community of linguistic phenomena, and brings no migration from the Tokelau Group to the southern groups, or the reverse. These are quite as important as the break (') for *k*, on which he bases the linguistic community of the Ellice, Tokelau, Samoan, Tahitian, South Marquesan, and Tubuai Groups; or the variation of *r* from *l*, on which he bases an eastern Polynesian Group, consisting of New Zealand, Chatham Islands, Tahiti, the Paumotus, the Cook Group, Mangareva, the Tubuai Archipelago, and Easter Island.

The radical mistakes made by these philological ethnologists are the attempts to draw inferences from the language without the culture, and the assumption that there was but one colonizing expedition. The extraordinary similarity of the dialects (Finck seems to acknowledge "dialects" as the proper term, for when he says "*Sprachen*" he always adds, "that

is to say, '*Dialekte*'") as contrasted with the countless variety of not merely dialects, but languages, in the Melanesian region and the Malayan region, if properly considered, might have saved them from the latter mistake. Even the few centuries which they seem to have in their minds as covering the history of the human race in Polynesia would have developed languages as distinct as, say, French and Spanish, or English and German. If we were to take into account the marvellous similarity of the Polynesian dialects not only in phonology and grammar, but in vocabulary, spread over an oceanic region as wide as Europe and Asia combined, we would not be far wrong in concluding that there have been thousands of migrations from every island to every other island; in short, a new sketch-map of the Polynesian migrations should so completely cross-hatch the central Pacific that it would look black. In other words, for centuries at least intercourse must have been almost unbroken amongst all the groups. If this means anything, it means that for a prolonged period all the Polynesians must have inhabited a large island or archipelago centrally situated, and also quarantined from other regions under a social, if not political, system that was practically a unity. The minute dialectic differences that arose must have been kept in bounds by the constant social intercourse that a single administrative system would allow—a system absolutely different from that of Melanesia or of Malaysia. The differences are no greater than those that separate the dialects of, say, Yorkshire and Somerset, or Scotland and Middlesex.

The consideration of the culture conveys the same impression; the ethnological differences are as negligible as the linguistic when placed beside the points of agreement. One can find as wide variations of culture and dialect in the purely German part of the German Empire. They seem to have arisen in the presence of each other, as well as of the predominant community of culture. In other words, they must have slowly developed during the immense period of time that certainly was taken to produce the practical identity of culture and language. This identity would have been shattered into strongly contrasted fragments had it been compelled to run the gauntlet of the limitless variety of Malaysia and Melanesia, not to speak of having to sail right in the teeth of the south-east trades, the only fairly constant wind on that route, the contrary wind being brief, fitful, and cyclonic.

There is, of course, a striking similarity between the languages of Polynesia, Melanesia, and Malaysia that makes many speak of them unitedly as the Oceanic language. But there is a phonological gulf between the Polynesian dialects on the one hand and the Malaysian and, still more, the Melanesian languages. Each of these two regions has its own range of sounds, with considerable community; but Polynesian has the peculiar and distinguishing sounds of neither—it has the simplest range of sounds that ever language had, all easily pronounceable by Aryan and, one may add, by Japanese organs of speech. It has a similar contrast in vocabulary: with any one of the Malaysian or Melanesian languages except Fijian it has never more than 20 per cent. of common words. It is the grammar that has led to their classification as one language; for none of them have practically any formal grammar—they all move in an atmosphere of particles, and there is a very considerable resemblance in the particles used. But this absence of formal grammar is the commonest characteristic of crossbred languages—*i.e.*, languages that have resulted from the permanent or continuous settlement of a masterful people amongst a people linguistically different; the formal grammatical peculiarities of both are

gradually dropped, and particles take their place, or variations of order of words.

The distinction which Max Müller drew between languages, classifying them into isolating, agglutinative, and inflective, according as they had no formal grammar, formal grammar with forms detachable from the stems, and formal grammar with forms undetachable, is no real distinction. There are few languages that have not at least traces of all three—isolation, agglutination, and inflection—either as vanishing habits or as neologisms. It is the phonology, or range of sounds, that really distinguishes languages. This cannot change—*i.e.*, the organs of speech cannot change, except by change of environment—*i.e.*, by change of climate or change of educative influences in the formative period of the organs of speech. The grammar and the vocabulary are constantly changing by loss, or addition, or development. Within the same zone of climate and physical environment the sounds do not change except by change of mothers—*i.e.*, by intermixture of races linguistically different.

But in the languages of the three regions referred to — Polynesia, Melanesia, and Malaysia—there is a considerable similarity of particles. This undoubtedly means that one language has saturated the languages of all three regions. The great variety of languages in Malaysia bars that as the region from which this language came ; the still greater variety in Melanesia still more effectually bars that. There is an easy solution when we turn to Polynesia, which has only one language, though it has many dialects.

But were this in conflict with the racial and cultural phenomena of the three regions it would have to be abandoned, or considerably modified, or conditioned. It is not, however. A visit to the Solomon Islands soon convinces even the superficial, untrained observer that the fundamental race of Melanesia is negroid : the woolly, tufty hair, the thick lips, the flattened nostrils, the projecting muzzle, and the absence of calves on the lower limbs are to be seen on all sides, quite apart from the dark colour which gave the region its name. The predominance of the round head and the low stature indicates the negritoes or pigmies as the branch of the negroid race that first peopled Melanesia. But there is a considerable infusion of tall stature, straight and wavy hair, light-brown and even auburn hair, European features, and light-brown colour ; especially in the eastern islands of the Solomons are the last three apparent. In the western Solomons and the Bismarck Archipelago, though the colour is close to black, the hair is often straight or wavy, and the profile is what we call Semitic, whilst tall stature is not infrequent. There can be no hesitation in homing this peculiar western Caucasianism to the west—*i.e.*, to Malaysia or the Asiatic Continent—and in homing the light-haired Caucasianism of the eastern islands to Polynesia. In Malaysia, again, we have, as the name implies, a strong admixture of Mongoloidism with the primeval negroidism and the secondary Caucasianism. When we turn to Polynesia we find the purest racial elements —fundamental Caucasianism, with a slight admixture of negroidism.

The culture exhibits similar phenomena. Polynesia is the realm of the patriarchate ; the pivot of relationship is the father. Right through Melanesia and Malaysia the matriarchate is the system ; the mother is the pivot of relationship : there is therefore no history, no preservation of the records of the past, no tradition, the mother being only a private person, and having no public events in her life to hand on the memory of to posterity ; the sons as well as the daughters belong to her and her kin, and do not count any relationship with the father and his relatives. The

patriarchate is at least thousands of years in advance of the matriarchate, for it makes history and tribal and political unities; the father hands on to the children, and he is the warrior and event-maker; hence, under the patriarchate, tradition accumulates into chieftainship and kingship. There is no broad realm of the patriarchate westwards from Polynesia till we reach India. That the Polynesian social system should have travelled tens of thousands of miles in frail canoes in the teeth of the trade-winds, and run the gauntlet of two matriarchal realms, has a touch of the miraculous in it or, in other words, seems contrary to the laws of nature.

It seems more in harmony with the possible, if not the probable, that whatever kinship lies between the cultures and the languages of these three regions has gone westwards out of Polynesia. And this is borne out by facts. Fiji, the nearest part of the two regions to Polynesia, has had its social system transformed from the matriarchal to the patriarchal; chiefship and tribe and tradition have arisen in the group. It is highly Polynesianized. When we get to the Solomon Islands, the nearest part to Fiji in the eye of the trade-winds, three islands have gone in parts through the same transformation—Malaita, Choiseul, and New Georgia; and their natives show a larger percentage of European features and light-brown hair than those of any others of the group; they are also most warlike, and go back furthest into the past with their genealogies and traditions. The influence of the patriarchate tapers off as we go farther west into Malaysia.

The purpose of this excursion into ethnology is to show how close to the absurd those philologists, like Finck, go who make the starting-point of Polynesian colonization the south (they should say rather the east) of the Solomons. The basis of the conjecture is a name often given to San Cristoval, the most easterly of the Solomons. Hale identifies Bulotu, the paradise and probable original home of Tongan and Samoan tradition, with Bouro, one of the most easterly islands of Malaysia. German ethnologists prefer, as a rule, to identify it with Bauro, the name referred to as applied to San Cristoval. But Bauro is only a district on the north-east coast of the island, and the natives prefer to call the island, if they have any name for the whole, Makira.

We get into the region of the miraculous when we start a patriarchal, tribal, genealogy-loving, chiefly Caucasian people from a matriarchal, kin-divisioned, short-memoried negrito island; and still nearer the miraculous when we start off, for nearly ten thousand miles of open oceanic wandering, a canoe expedition right in the teeth of the only constant winds, the trades that blow eight or nine months of the year, from an island that had only shallow shells of canoes, unfit for crossing anything but fairly narrow straits in calm weather or a favourable wind. The Polynesians were the only people in the world that learned oceanic navigation before the use of the compass. And it needs some exceptional, if not catastrophic, goad of nature to explain the exception; that we have in the subsidence, probably often slow, but probably as often sudden, of the central island zone of the Pacific that stretches south-east from the southern end of Japan across the Equator, even as far as Easter Island. This manifestly went on for hundreds of thousands of years; and any humans that got on to the islands of this zone would, time and again, have to go off the best way they could find in search of other standing-places in the great flux of waters. Nowhere else in the history of our world has such a goad been held by nature to the backs of human beings. We may be quite certain that the regions to the west would get flooded with migrations from water-logged Polynesia.

Art. XX.—*Notes on New Zealand Fishes: No. 2.*

By Edgar R. Waite, F.L.S., Curator, Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1911.*]

Plates X–XII.

6. Aegoeonichthys appelii Clarke.

Plate X.

To Mr. A. Hamilton, Director of the Dominion Museum, Wellington, I owe the privilege of examining the remains of a specimen of this species. This specimen is, I believe, only the second known; it is in rather deplorable condition, being in two pieces, and has been otherwise so cut about that no fully satisfactory description can be made. Mr. Hamilton writes, "Please do whatever you like with the skin; it is so torn and knocked about that you will find description a difficult matter. The specimen was caught by some fishermen on a line at the Heads (Port Nicholson), and used by them for bait. Somebody saw it in the boat, and brought the remains to me."

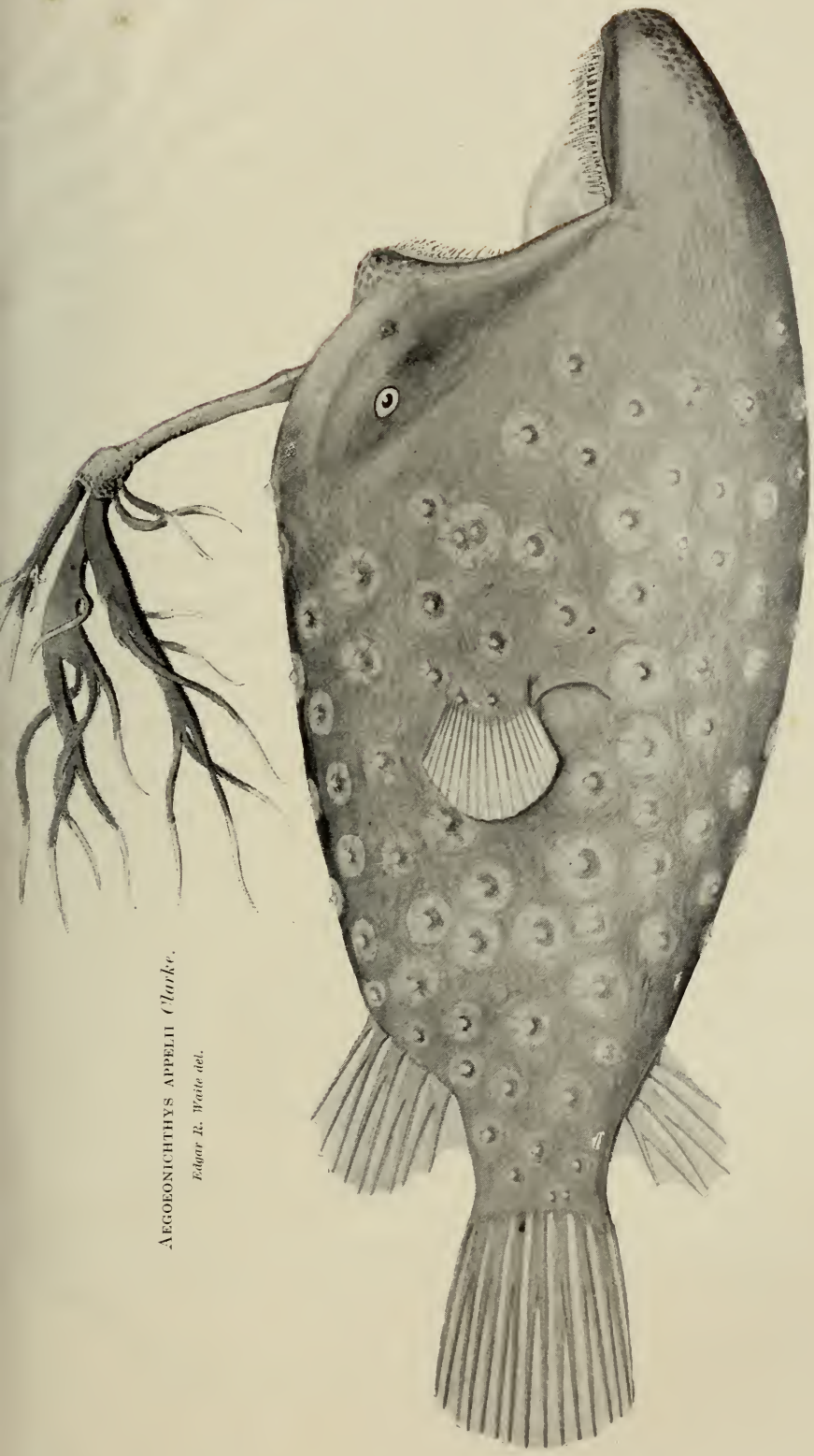
Though the specimen is in a very dilapidated condition, the rarity of the species makes it advisable to attempt to extract some few grains of information from the remains, and these will be useful in the case of definite and fixed characters.

The type specimen was described and figured as having the head and body strongly depressed, and as the author had the specimen entire, and probably unmutilated, his description may be correct; judging from our remains alone, I should have said that the head, body, and tail were all compressed, but the jaws appear to be so extensible and dilatable that the contour of the head may perhaps be altered with the varying positions of the jaws. Respecting this subject, Günther* writes, "According to the figure, *Aegoeonichthys* would appear to be much more depressed in shape than *Himantolophus;* however, we must remember that these flaccid deep-sea fishes may assume, or be made to assume, very different appearances."

By careful piecing together it is found that the whole of the skin of one side and of portion of the other remains, so that it is possible to correctly render an account of all the fins, and the number and disposition of the dermal scutes. The whole of the body, with the exception of the vertebrae, is missing; but if all the vertebrae are represented, as I believe they are, their total number is 17, and this is also the number supplied for *Halieutaea*, another member of the order.

Of *Aegoeonichthys* Günther also writes, "Unfortunately, nothing is known of the gills of this fish, which, as regards grotesqueness of form, surpasses the fishes of the preceding genus (*Himantolophus*). It is evidently closely allied to *Himantolophus reinhardtii*, and I therefore suppose that it possesses the same number of gills. If this should prove to be the case, the question will arise whether it should be kept as the type of a distinct genus."

* Günther, "Challenger Reports," vol. 22, 1887, p. 51.



Aegoeonichthys appelii *Clarke*.

Edgar R. Waite del.

Face p. 194.]

The gills in the present example are, fortunately, preserved, but as I cannot refer to Lütken's paper* in which *Himantolophus reinhardtii* was described and figured, I am not in a position to decide the question as to generic identity. It is, however, possible that with the aid of the following description others more fortunately situated may be able to do so.

The figure published in illustration of Clarke's paper† is somewhat crude, and, gauged by the characters of our example, incorrect as regards the cephalic tentacle and the number and disposition of the dermal scutes. I have therefore thought fit to refigure the species from the assembled remains of the specimen intrusted to me. I have also essayed a description of the specimen, but owing to the imperfect condition it will be understood that the proportional measurements are merely approximate, or, it may be, even conjectural. These remarks apply, however, only to the relative width and depth of the body and head, the bones being so flexible that the character of the head may be made to assume either depressed or compressed condition, while, as before stated, the absence of the soft portions of the body renders its original shape largely conjectural.

D. I, 5; A. 4; V. 0; P. 17; C. 9; Vert. ?17.

Head enormous and grotesque, its length half that of the total, computed from the tip of the snout to the base of the caudal fin; its depth is one-fifth greater than its length, and its width is a little more than half its length. The cheeks are subvertical, and the eye is placed in a large shallow depression rather high in the head. The eye is very small, about 12·3 in the head; it lies midway between the tip of the snout and the supraorbital spine; the latter marks the termination of the supraoccipital ridge; this is widely separated from its fellow where it originates behind the premaxilla; these ridges diverge behind, but are somewhat contracted in the middle. The interorbital space is deeply concave, and from its centre the remarkable tentacle takes its origin.

The gape is very wide, and the mandibular articulation is in advance of the eye, and even in front of the tip of the snout. When closed the mouth is almost vertical.

Teeth.—The teeth are in about three irregular rows, the innermost containing the largest; they are spine-like, slightly recurved, and depressible; they are slightly longer in the lower than in the upper jaw; the longest are one-fifth more than the diameter of the eye. There are no teeth on the vomer or palatines. Upper pharangeal teeth only are present; they form two clusters, which appear to act in apposition, the teeth of each group being directed towards each other to form a grasping apparatus. The teeth are similar to those in the jaws, but shorter and stouter, their combined number being 14. There are no teeth on the lower pharangeals.

The chin forms the anterior contour of the head, projecting far beyond the mouth when it is closed. There is an extensive frenum behind the teeth in both jaws.

The branchiostegals are 6 in number on each side; they do not bear teeth, as stated by Clarke, who possibly wished to express the character of the branchial arches. The gill-opening is small, and placed below the base of the pectoral fin. The gills may perhaps be denoted by the formula applied to *Himantolophus*—namely, $\frac{1}{2}2\frac{1}{2}$ pairs—but a more detailed account of their character will be advisable,

* Lütken, K. dansk. Vidensk. Skriv., 1880, p. 309, pl. 1, 2.

† Clarke, Trans. N.Z. Inst., vol. 10, 1878, p. 245, pl. 6.

The outer branchial is free only in its posterior half, the anterior portion being adnate to the ceratohyal. This attached portion only bears gills; they are much smaller than those of the other arches, on which they are of considerable length. There is no trace of paired arrangement in the gills of this outer arch. A paired disposition is apparent in the gills of the two middle arches, for, though the rays are set in continuous series, they are of heteracanth nature. The inner arch is wholly adnate to the membranes at the lower part of the tongue, and is fully furnished with gill-rays. The gill-rakers are spiny tubercles; there are 12 on the first arch, one of which is on the upper limb, just above the angle; the rakers on the median arches are in two rows, arranged alternately, there being 19 on the second arch.

Fins.—Some idea of the character of the dorsal tentacle will be derived from Clarke's figures, but as it was evidently imperfect, and is even more complicated than drawn and described, the following description will not be out of place:—

The tentacle lies in a deep groove between the supraorbital ridges, its bulbous base being rather nearer to the mouth than is the eye; the shaft is very stout, and it terminates above in a large semispherical bulb, its total length from base to summit being 1·7 in the length of the head. From a cup in the summit of the bulb arises a freely movable stout tentacle, which divides at a short distance above its insertion, each branch throwing off 2 smaller twigs at about half its height. Inserted in the bulb and behind the cup are 2 thick branches, which, however, arise from a common base: they become flattened distally, and each, after throwing off a twig from its inner side, divides into 3 arms; these are again subdivided, but the divisions are not the same in the two branches The illustration accurately depicts the condition. Also, on the hinder part of the bulb, but nearer its base and sides, are two other small twigs. The word "frond" would perhaps be more appropriate, for the whole tentacle may be likened to a plant of *Fucus*, the so-named twigs being quite like the fronds of a seaweed, while the main and secondary stalks answer to the stem and branches of the plant. There are, in all, 20 terminal fronds, and the distal portion of each is nacreous white, and is no doubt luminous in life. When the tentacle is bent forwards these luminous tips dangle just in front of the mouth, and are no doubt very effective lures. It will be apparent that the tentacle was incomplete in the type specimen, the stalk arising from the middle of the cup being absent, and doubtless leading its author to conclude that the substance within the cup was luminous, though he does not actually say so.

The dorsal fin has a slightly more forward insertion than the anal, and has one more ray. The first is simple, the other four being divided nearly to their bases. The third is the longest, being 3·2 in the head. The last ray is connected to the peduncle, just free of the upper caudal ray. The anal is very similar, but the first two of its 4 rays are simple. The pectoral is short and rounded, and is placed nearly midway between the end of the snout and the base of the caudal rays. The caudal is large and rounded, arising from a very compressed and short peduncle, whose depth is equal to the longest dorsal ray.

Armour.—The skin is soft and loose, warty on snout and chin, and, excepting the top of the head, cheeks, lower jaw, and all parts in front thereof, studded with round cartilaginous scutes, each of which bears in its centre a hard low thorn with roots radiating into the body of the scute.

Some of the scutes are much larger than others, and their exact number and disposition are shown in the illustration. The covering of the main stalk of the tentacle is formed of a mosaic of very small scutes, which also bear spines, but they are reduced to hard tubercles.

Colours.—After long immersion in preservative the general colour is a pale-flesh tint; the margin of the jaws, the post-dental frenum, the space around the eyes, and the wart-like elevation on the chin are brown; the mid-line of the back and part of the stalk of the tentacle are also brown; the branches of the tentacle are black, but their tips are white.

Some Measurements.—Extreme length, chin to end of caudal, 410 mm.; length as basis for comparisons, 270 mm.; length of head to gill-opening, 135 mm.; diameter of eye, 10 mm.; length of tentacle-stalk, 78 mm.; extreme length of tentacle, inclusive, 205 mm.

7. Saccarius lineatus Günther.

In 1861 Günther* diagnosed a new genus and species of the *Pediculati* under this name. The type was a single specimen taken at the Bay of Islands, New Zealand, presented to the British Museum by Sir A. Smith.

The reference is duly included in the "Catalogue of New Zealand Fishes,"† also in the "List of New Zealand Fishes," likewise issued by Captain Hutton.‡ In his later list§ the reference is entirely omitted, and is not, in consequence, found in the "Basic List of the Fishes of New Zealand."‖

This Antennariid is duly catalogued by Gill,¶ and, as I have not seen any note discrediting the stated habitat, I presume that the omission by Hutton was purely accidental. I therefore take this opportunity of drawing attention to the omission, in order that it may not be again overlooked. The type specimen appears to be the only example so far known.

8. Oreosoma atlanticum Cuvier and Valenciennes.

Plate XI.

During a recent visit to the Newtown Museum, Wellington, I noticed in one of the exhibition cases a small fish which seemed familiar, though at the time I was unable to name it. I find it to be an example of *Oreosoma*, and the consciousness of recognition is explained by the figures of Cuvier and Valenciennes, and the copy by Goode and Bean, familiar to all ichthyologists. The specimen was kindly lent to me by Mr. Perry, the librarian in charge, who informed me that the specimen was obtained alive on the beach at Lyall Bay, near Wellington.

The genus *Oreosoma* is represented by a single species, of which only one example was previously known: it was taken in the Atlantic, and is only $1\frac{1}{3}$ in. in length. This little fish was described in 1829 by Cuvier and Valenciennes, who state that the name *Oreosoma* was given in allusion to the great cones on the body, which resemble sugar-loaves, and are so rugged and bold that a drawing of the fish resembles a chart of a volcanic country.

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* Günther, Cat. Fish. Brit. Mus., vol. 3, 1861, p. 183.
† Hutton, Cat. Fish. N.Z., 1872, p. 30.
‡ Hutton, Trans. N.Z. Inst., vol. 22, 1890, p. 280.
§ Hutton, "Index Faunae Novae-Zealandiae," 1904.
‖ Waite, Rec. Cant. Mus., vol. 1, 1907.
¶ Gill Smiths. Miscell. Coll., vol. 19, 1880, p. 222.

It was the evident intention of the authors to allude to these cones in naming the species, for on the plate accompanying the description the figures are designated *Oreosoma coniferum*, whereas in the text the name *Oreosoma atlanticum* is used.

The New Zealand example exhibits characters which are not referred to in the description of the Atlantic specimen, and these will be mentioned later. The following is a description of the fish taken at Lyall Bay :—

D. VI, 30 ; A. III, 28 ; V. I, 7 ; P. 20 ; C. 13 + 4 ; L. lat. 90.

Length of head, 2·64 ; height of body, 1·3 ; length of caudal, 4·7 in the length ; diameter of eye, 2·27 ; interorbital space, 2·63 ; and length of snout, 2·94 in the head.

Head compressed, eyes lateral, the supra- and post-orbital ridges armed with a number of denticles, of which one in the middle of the series is larger, forming a short spine. Preopercle very oblique ; a ridge across the opercle. Eyes lateral. Interorbital space flat. Nostrils close together, in front of the upper anterior margin of the orbit ; the anterior nostril large, directed forward. Jaws equal ; mouth protractile ; the cleft subvertical. Dentary produced downwards into an acute angle. The maxilla, whose length is less than the diameter of the eye, scarcely reaches the anterior margin of the orbit when the mouth is closed. Gills 4, a small orifice behind the fourth ; gill-rakers moderate, bristle-like ; pseudobranchiae present.

Teeth.—The teeth are extremely small and villiform in character. A narrow band exists in the lower jaw, but no teeth are to be found in the upper jaw ; they are present on the vomer, but there are none on the tongue or palatines.

The upper and hinder parts of the body are compressed and normal ; a pronounced median keel runs from the occipital region to the origin of the dorsal fin, lying between the swellings on which the dorsal cones are situated. The whole of the ventral portion of the body is enormously, naturally, and permanently distended, so that a section across the body is not unlike that of *Lactophrys trigonus*.

Fins.—The dorsal fin arises midway between the end of the snout and the base of the caudal. Its spines are short, the second and longest being little more than half the diameter of the eye. The first spine is very short, and the second and following are graduated. The longest rays occur behind the middle of the second dorsal, and are nearly as long as the eye. The anal spines are quite small, almost hidden within the folds of the posterior dilatations of the abdomen. The rays are similar to those of the dorsal, but have a somewhat more posterior hinder insertion. The ventrals are noticeably separated, and of considerable length, the slender spine being one-half longer and the first ray twice the length of the orbit. The pectoral is rounded, and its length is equal to the diameter of the eye. The feeble tail is also rounded, and the depth of the slender peduncle is less than half the eye-diameter.

Scales.—The scales are nowhere imbricate, but form a mosaic, the components varying greatly in different parts of the body. They are minute on the interorbital space, small on the cheeks and opercles, and on the upper and hinder part of the body. They are larger immediately behind the opercles and on the sides of the body, while those on the ventral surfaces are tubercular. All are 6-sided and concentrically striated. The lateral line is well marked : it originates behind the opercle and rises above the

Oreosoma atlanticum *Cuvier and Valenciennes.*

Edgar R. Waite del.

pectoral fin to a point in advance of the first dorsal cone; it thence drops to the mid-line of the body and passes along the middle of the caudal peduncle.

Cones.—The remarkable cones which give the fish such a striking appearance are disposed as follows: The swellings on each side of the dorsal ridge above referred to support 2 pairs of small size; the hinder pair lie at the base of the dorsal spines, and are directed outwards; the pair in front of these have a more upward aspect. All the other cones exist on the ventral portion of the body; the largest form a series of 5 pairs disposed along the lateral margin, the centre one on each side being the largest, and directed straight from the body, those before and behind being divergent. A smaller cone is placed immediately in front of each ventral fin, and a similar, though larger one, on each side of the vent between these ventral and anal cones. There are 3 pairs of much smaller ones, which thus complete the vertical armament. In these latter each cone is set close to its fellow. The mosaics in the mid-ventral line form small tubercles, but quite distinct in size and character from the true cones, which, as will be seen, number 12 pairs—namely, 2 dorsal, 5 lateral, 2 subventral, and 3 ventral. The cones, which arise from an enlarged series of mosaics, are as high as, or higher than, their diameter, and are sculptured with both radiating and transverse striae, the former being straight and the latter wavy. The area between each radial is flat. These correspond in number with the basal mosaics, of which there are 16 surrounding the largest cone —namely, that in the middle of the lateral series.

Colours.—The ground-colour is brownish-yellow, and the markings form wide open reticulations, consisting of a black line merging into bluish-grey, which extends so as to nearly obscure the ground-colour. The latter remains fairly pronounced on the cheeks, the lower edge of the caudal peduncle, and an area at the base of the anal fin, due to the absence of markings on these parts. The membranes of the first dorsal fin and of the anterior ventral rays are black; the other fins are colourless.

Length, 80 mm.

One specimen only.

There is a temptation to give the Pacific fish a distinct specific name, not only on account of certain described differences in the two known individuals, but also in consideration of the widely separated habitats, the one being taken in the Atlantic and the other in the Pacific Ocean. The fish must have rather limited powers of progression, for its locomotory fins are feeble, and the general conformation of the body is opposed to even moderate progress. The original specimen was supposed to have been taken in the surface-net, and, as the New Zealand specimen was secured alive on the beach, it becomes fairly evident that we have either two very closely allied species, or, like *Tetragonurus*, a single species of pelagic habit, of which examples have been obtained from both Atlantic and Pacific Oceans without any intermediate occurrences.

The differences noted between the two specimens may be due to certain characters in the smaller one having been overlooked. It is unlikely, for example, that the 3 spines preceding the anal rays were absent, or that the ventrals had only "le nombre ordinaire de 1/5." Other differences may be noted in the descriptions of the dental armature. The French authors apparently found teeth in both jaws, whereas my specimen exhibits them in the lower jaw only. There is agreement as to the presence of teeth on the vomer, but I find none on the palatines, their presence being

affirmed by Cuvier and Valenciennes.* They describe the colour as that of cedar wood, but do not refer to any markings, though the illustration shows traces of large reticulations very similar though less extensive than in our specimen.

Günther† originally included this species with the perch-like fishes, but afterwards accepted Lowe's‡ suggestion that it was a member of the *Zeidae.* An examination of this second specimen supports the conclusion which is adopted by Goode and Bean,§ who give the genus the status of a sub-family, *Oreosominae.* Though Cuvier and Valenciennes counted only 5 rays in the ventral fin, the fact of our example having 7 brings the species into still closer agreement with the *Zeidae.* The genus differs from other members of the family by having the dorsal spines very short (shorter than the rays), and in the development of large cones in place of the usual bony plates, though they cannot be said exactly to replace them. Boulenger|| is of opinion that *Oreosoma* is the young form of a fish allied to *Cyttus.* It is admitted that the characters of the fish are of the bizarre nature commonly associated with very young Scombroid and other fishes, and such might be found in examples but little over an inch in length. I am not aware, however, if such characters are likely to persist so completely in a specimen over 3 in. in length.

9. Eurumetopos johnstonii Morton.

Plate XII.

The Australian Museum, Sydney, possesses a mounted example of *Eurumetopos johnstonii,* sent from Tasmania by the late Alexander Morton, the author of the genus and species. He thought it was a Serranid, stating that "it bears in many respects a close resemblance to the *Oligorus.*" I examined the specimen referred to, many years ago, and came to the conclusion that it was referable to the *Stromateidae.* It is, however, only quite recently that I have been able to satisfy myself on this point, and to ascertain more closely its systematic position and affinities.

Last month (August 1911) Messrs. Dennis Brothers, of Christchurch, sent a fish to me for determination, with the remark that, notwithstanding their long experience in the New Zealand fish trade, they had never seen one like it before. On making inquiries I found that the specimen was one of five which the firm had secured, and that other fish-merchants had also obtained examples of the same kind, but had readily disposed of them before I became aware of the fact. Somewhat later the daily newspapers contained an announcement that some large fishes were being obtained at the Chatham Islands, and, though no one was able to give them a name, they proved to be excellent eating, and it was proposed to put them on the market as a regular commodity. From the popular description supplied I strongly suspected that the Chatham Island fishes would be found to be of the same species as those sent to Christchurch, and therefore enlisted the kind aid of Mr. A. Hamilton, Director of the Dominion Museum, as the fish companies operating at the Chatham Islands ship their catches

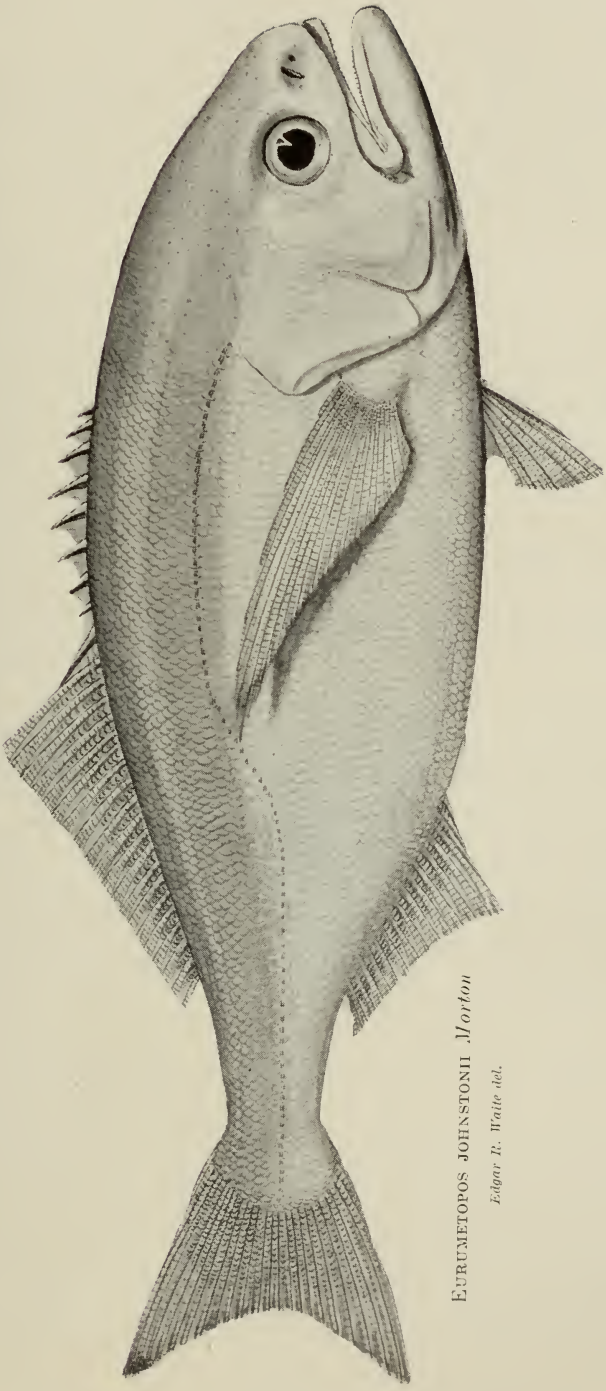
* Cuvier and Valenciennes, Hist. Nat. Poiss., vol. 4. 1829. p. 515, pl. 99 (*O. coniferum*).

† Günther, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 214; vol. 2, 1860. p. 396.

‡ Lowe, "Fishes of Madeira," p. xii.

§ Goode and Bean, Oceanic Ichth., 1895, p. 228, and fig.

|| Boulenger Camb. Nat. Hist. Fishes. 1904. p. 683.



Eurumetopos johnstonii *Morton*

Edgar R. Waite del.

Face p. 200]

direct to Wellington. Mr. Hamilton was fortunate in being able to secure a specimen for me, which confirmed my supposition, and it is this larger specimen which forms the basis of the subjoined description.

I understand that the occurrence of the fishes at the Chatham Islands was of short duration only, and that, though they were quite plentiful at the period of their appearance, they are not now to be obtained.

During a subsequent visit to Sydney I was permitted to re-examine the specimen of *Eurumetopos johnstonii*, and compared with it a cast of the smaller of our two examples. I found them to be specifically identical.

The Tasmanian specimen exhibits the following characters :—

B. VII ; D. VIII, I, 20 ; A. III, 15.

The length of the head equals the depth of the body, and the pectoral is as long as the head.

The radial formula, as given by Morton* in his original description, appears to have been slightly mutilated by the printer, producing a very misleading result, which in all probability accounts for the non-recognition of the affinities of the species for such a long period. The figures D, 9 1–9, were intended for D. 9, 19, or, as now more usually written, D. VIII, I, 19. The anal formula is III, 13.

The following is a description of the Chatham Island specimen : B. VII ; D. VIII, I, 20 ; A. III, 15 ; V. I, 5 ; P. 20 ; C. 24 + 6. L. lat. 84 ; L. tr. 18 + 34. Vert. 10 + 12 = 22.

Length of head, 3·0 ; height of body, 2·7 ; and length of caudal, 5·5 in the length ; diameter of eye, 5·2 ; interorbital space, 2·7 ; and length of snout, 4·0 in the head.

Head rounded, compressed, naked and porous above, tumid over the nostrils ; the latter are close together, the anterior being circular, while the posterior one is an oblique slit lying midway between the end of the snout and the eye ; snout truncate ; the interorbital is broad and convex ; the eye is relatively low in the head and is somewhat overhung by an obtuse ridge. The cleft of the mouth is horizontal, and the maxilla, which has a supplemental bone, extends to below the second third of the orbit ; its distal portion is rounded and its width nearly half the diameter of the eye. The opercular bones are thin and entire, and the angle of the preopercle is greatly, though roundly, produced. Gill-membranes united far forward, not attached to the isthmus ; gill-rakers long, 21 in number on the first arch, of which 16 are on the lower limb ; pseudobranchiae present, but ill-developed.

Teeth.—The teeth are confined to the jaws, the rest of the mouth being edentulous ; they are small, set close together, and form a single series along the whole margins of both jaws.

Fins.—The dorsal fin commences over the edge of the operculum ; the fourth and fifth spines are the longest, three-fourths the diameter of the eye ; the last spine is continuous with the rays, the anterior of which is the longest and twice the diameter of the eye. The anal commences beneath the eighth dorsal ray, and is similar in character to the dorsal, terminating more posteriorly, however. The pectoral is falcate, and its seventh ray is as long as the head. The ventral spine is long and slender, its length one-half more than the diameter of the eye ; the length of the first ray is twice the orbital diameter ; the fin lies below the pectoral. Caudal emarginate ;

* Morton, Proc. Roy. Soc. Tasm., 1888, p. 76, with plate.

the peduncle long and narrow, its depth one-fourth more than the diameter of the eye.

Scales.—Head generally naked, but with scales on the opercles; upper part of head with a spongy porous integument. The body-scales are not markedly deciduous, are of moderate size, and finely denticulated; they extend on to all the vertical fins. The lateral line does not follow the curve of the back, excepting for its anterior half, the hinder part being almost straight.

Length, 945 mm. The type was 990 mm., doubtless measured to the end of the longest caudal ray.

Colours.—Steel-blue above, silvery beneath.

The genus *Eurumetopos*, of which *E. johnstonii* is the type and only known species, may be thus defined: Body oblong, compressed; snout obtuse; mouth large; teeth present only in the jaws. Premaxillaries slightly protractile, maxillaries with supplemental bone; they are not entirely concealed by the preorbitals when the mouth is closed. Opercular bones thin, entire; branchiostegals 7; gill-membranes united far forward, not attached to the isthmus, pseudobranchiae developed; gill-rakers long; scales of moderate size, fairly adherent, lateral line not concurrent with the dorsal profile. A single dorsal fin with about IX, 20 rays; anal with about III, 15 rays; pectoral pointed, with 20 rays; ventrals below the pectorals. Vertebrae 22.

The genus appears to be sufficiently established, and finds its nearest ally in *Psenopsis* Gill, differing in the larger mouth, the character of the maxillaries, the more adherent scales of relatively smaller size and their development on to the bases of the dorsal and anal fins. The lateral line is not concurrent with the dorsal profile, and the number of rays in the vertical fins is noticeably smaller.

The following notes are supplied for the convenience of those wishing to make a further comparison: In 1862 Gill* erected the genus *Psenopsis* for *Trachynotus anomalus* Schlegel, a species taken in Japanese seas.† The affinities of the fish were previously recognized by Bleeker (1853),‡ who placed it in the genus *Psenes*. Regan§ has more recently added *Bathyseriola cyanea* Alcock,‖ from Indian seas, to the genus *Psenopsis*, remarking, "There can be no question that these two species belong to the same genus, although their relationship has not hitherto been suspected, and the two species are very closely allied."

EXPLANATION OF PLATES.

Plate X.

Aegoeonichthys appelii Clarke. Less than half natural size.

Plate XI.

Oreosoma atlanticum Cuvier and Valenciennes. Nearly twice natural size.

Plate XII.

Eurumetopos johnstonii Morton. One-fifth natural size.

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* Gill, Proc. Acad. Phil., 1862, p. 157.

† Schlegel, Fauna Japon, Poiss., 1850, p. 107, pl. 57, fig. 2.

‡ Bleeker, Verh. Bat. Gen., vol. 26, 1853, p. 104.

§ Regan, Ann. Mag. Nat. Hist. (7), vol. 10, 1902, p. 130 (also see for further references.)

‖ Alcock, Cat. Indian Deep-sea Fishes, 1899, p. 43, pl. 17, fig. 1.

[The three papers last quoted are the only ones I have been able to consult, but Mr. McCulloch has kindly assisted me by referring to others in the Australian Museum library.]

Art. XXI.—*New Species of* Lepidoptera, *with Notes on the Larvae and Pupae of some New Zealand Butterflies.*

By George Howes, F.E.S., F.L.S.

[*Read before the Otago Institute, 1st August, 1911.*]

The following are descriptions of some new moths recently collected in the Otago Province.

Larentia cinnabari sp. nov.

Expanse—in ♂, 20 mm.; in ♀, 22 mm. Forewings pale orange, marked with brown and light ochre. Basal area brown, extending to about $\frac{1}{6}$, where it is edged with a dark line, then a pale-ochreous thin line, which is followed by pale orange to $\frac{1}{3}$. A dark-brown area from about $\frac{1}{3}$ to $\frac{2}{3}$, edged on both sides with a pale-ochre line. This brown area is bent out towards termen at centre of wing, and slightly constricted below. Subterminal line appears as dark shading on costa, and very faintly below. An oblique shaded patch below apex. With the exception of these markings, from $\frac{2}{3}$ to termen is pale orange. There is a terminal series of small dark dots. Cilia purplish-brown, darker at base. Hindwings uniform orange, with slight dark dots along termen. Cilia purplish-brown. In the ♀ the markings are the same as in the ♂, but the moth is paler. Considerable variation in depth of colouring and extent of the dark markings showed in the specimens taken.

Larentia cinnabari. × 2.

Appears to be close to *bulbulata*, which it resembles in appearance and habits. I am indebted to my brother, Mr. A. A. Howes, for the finding of this moth, he having first noticed it in the same locality in the previous year.

Taken in fair numbers amongst tussock in swampy places in the Garvie Mountains and at the Cinnabar Gold-sluicing Company's claim, in November, 1910.

Dasyuris transaureus sp. nov.

Four specimens; 19 mm. ($\frac{3}{4}$ in.). Palpi long, with dense long hairs. Antennae simple in both sexes. Forewings light ochre, marked with dark brown and golden orange. Dark-brown area at base, followed by a thin ochre line. A small golden patch continuing in dark brown to dorsum. A thin ochre line at $\frac{1}{3}$, followed by a wider dark-brown area. An equally wide ochre line at $\frac{1}{2}$, followed by a broad dark-brown area, which is interrupted at middle by a golden triangle. A thin ochre line follows, edged terminally with golden, which is indented on terminal side, where the veins cross. A dark-brown area to termen, with a faint subterminal

Dasyuris transaureus. × 2.

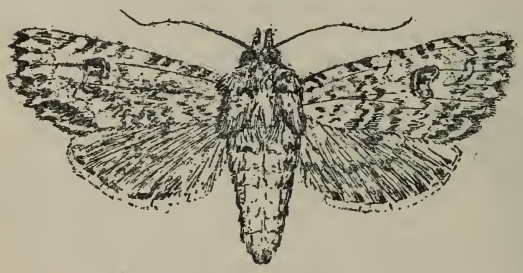
line in ochre. The veins crossing this area marked in golden. Cilia dark ochre, barred with brown. The markings continue on through the hindwings, the only difference being that there is more golden colouring, and the cilia are light ochre barred with brown.

The small size of this insect, together with the triangular-shaped golden marking cutting across the other markings, makes this moth very distinct. It is with some hesitation I place it in the *Dasyuris*. It may have to be removed later.

Taken on the Garvie Mountains, near Nevis, 20th November, 1910.

Morrisonia pansicolor sp. nov.

Three females, two males; 29 mm. Head and thorax ochreous, slightly tinged with rufous. Antennae filiform, rufous. Crests well defined, dotted with rufous. Abdomen ochreous, in ♀ dotted with minute dark specks, ochreous-rufous in ♂, with strong crests, especially the anal. Forewings ochreous, suffused with rufous; all markings rufous. Subbasal line double, much broken, double line at $\frac{1}{3}$ bending strongly outwards at centre of wing. A mark on costa at $\frac{1}{2}$, followed by two marks over reniform, which continue through reniform as faint jagged lines across wing. An indistinct subterminal line formed by a series of dots. Orbicular obsolete. Reniform filled with dark rufous. Veins faintly marked with rufous. Cilia ochreous. Hindwings ochreous, centre of wing clouded with rufous brown. Discoidal spot well defined. A faint series of subterminal dots. Cilia whitish-ochreous, with a darker line at base. Underside pale ochreous. Curved post-medial line across both wings. Reniform and discoidal lunule well defined.



MORRISONIA PANSICOLOR × 2.

MORRISONIA MOLLIS. × 2.

Taken in November, at Dunedin, at "treacle."

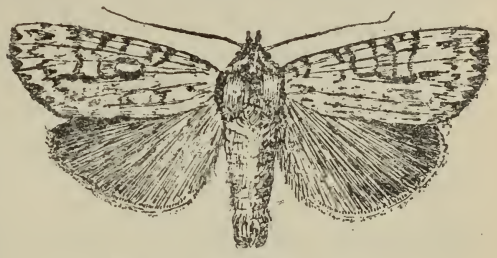
The moth is so close to *mollis* that the first specimens I took I thought were that species. Subsequent captures, which gave me both sexes in both species, placed the matter beyond doubt.

My last illustration of *mollis* being so unsatisfactory, I am giving another drawing of it, along with *paniscolor*. In *mollis* the reniform is clear, in *paniscolor* filled with dark rufous.

Morrisonia sequens sp. nov.

♂, 31 mm.; ♀, 34 mm. Head and thorax grey, strongly crested. Antennae filiform. Abdomen ochreous grey, crests slight. Forewings

bright grey, irrorated with fuscous. A jagged subbasal line, strongly marked on submedian fold, where it turns abruptly towards base. A dark line across wing at $\frac{1}{3}$, double, space between double lines grey (not irrorated), a dark mark on costa at $\frac{1}{2}$, followed by two more above reniform. Subterminal line faint and suffused. A terminal series of black points; a few dark points outline veins. Orbicular faint, but with a well-defined line along lower edge. Reniform defined by a dark line below and on terminal edge. Cilia grey, mixed with fuscous. Hind-wings brown, darker towards termen. Cilia brown, with fine paler line at base. Tips grey-white.



Morrisonia sequens. × 2.

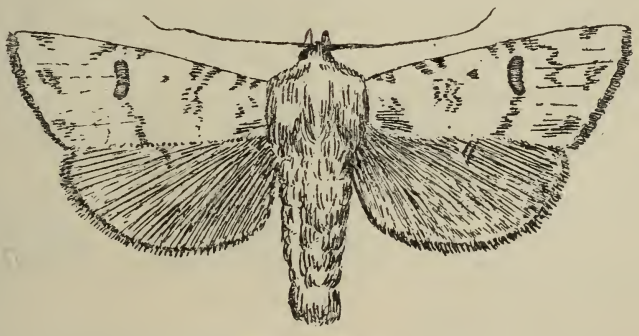
Taken at Whakarewarewa, North Island, on the 15th February, 1910, by Dr. G. B. Longstaff, F.E.S., whom I have to thank for the privilege of describing this moth.

The well-defined line below reniform and orbicular readily distinguishes this from *phricias*, which it is very close to—much closer than *M. longstaffii*. Neither has it the ferruginous markings of the latter.

Morrisonia pascoei sp. nov.

♂, 38–40 mm.; ♀, 36–38 mm.

♂. Antennae filiform, reddish-brown. Palpi, legs, and face reddish-brown. Thorax and crests reddish-brown with slight fuscous irroration. Crests well developed. Abdomen slightly fuscous, with crests strong; ochreous at sides. Anal tuft well developed, reddish-ochreous. Forewings red-brown with fuscous markings. Subbasal line double, very indistinct; a double line at $\frac{1}{3}$, also indistinct; another before reniform, more plainly marked towards dorsum. Two faint jagged lines, then faint subterminal line



Morrisonia pascoei. × 2.

hardly traceable at apex but outlined by a dark suffusion on both sides at about vein 7, then forming two nearly equal dentate marks, then again suffused on both sides at about vein 3 to close to tornus. Reniform deep fuscous, slightly edged on outer side with a thin ochre line. Orbicular obsolete. Veins faintly marked with fuscous. Cilia light

reddish-brown, with a lighter line at base. Hindwings fuscous-brown with red-brown suffusion along termen. Cilia red-brown, with ochreous line at base, and ochreous tips. Discoidal lunule shows faintly.

♀. Forewings pale ochreous. Marks as in male, but slightly less defined. Cilia lighter than in male. Hindwings lighter than in male.

The underside of both sexes is well marked with a well-defined reniform marking and discoidal lunule, also a well-defined line at about ⅔ passing right across both wings. In both sexes varieties occur with a strong fuscous suffusion from base above dorsum to near tornus, as seen in some specimens of *Morrisonia omoplaca*. Specimens such as these might be better to illustrate from, but apparently are not the typical form. The forewing of the moth being dark in colour, with few determined markings, makes a poor illustration.

Apparently close to *rubescens*, but more strongly crested, deeper in colour in the ♂, lighter in colour in the ♀. The subterminal line in *rubescens* is more deeply indented than in *pascoei*.

The first specimen came to "sugar" at Orepuki, 1st September, 1910 (a ♀). In November of the same year I took another at Queenstown (♂), and this year Mr. M. O. Pasco has been kind enough to send me about twenty taken at "treacle" at Queenstown in October. As it is through Mr. Pasco's kindness I have the chance of describing from such a good series, I am naming the moth after him.

The Larvae and Pupae of some New Zealand Butterflies.

In Hudson's "New Zealand Moths and Butterflies" we have details of the life-histories of most of our butterflies. The following additional notes may prove of interest. Owing to inability to devote special time to the larvae taken, the information here given is but scrappy and incomplete.

Chrysophanus boldenarum.

This little butterfly appears to be commonest on the Canterbury river-beds. It frequents patches of *Donatia*, flitting in dozens over the heated shingle patches. The first specimens appear about October, and I have taken it as late as March.

On the 20th November, 1909, I found larvae and pupae of this butterfly under stones in the Makikihi River bed. I was successful in rearing three. These all emerged on or close to the 18th December, 1909. In November, 1910, I again found the larvae at St. Andrew's, Canterbury.

Larva. Pupa.

Chrysophanus boldenarum. × 4.

A point which appears to me of great interest was that in each case the larvae and pupae were under stones that also sheltered ants' nests, and at least two of the chrysalids had ants running over them when I lifted the stone. Both these chrysalids produced butterflies. As certain of the *Lycaenidae* in other countries have been taken in conjunction with ants, this point in connection with one of our New Zealand butterflies promises to be worth investigating.

In appearance the caterpillar is rather slug-like, being very "deep" for its length, with the head small.

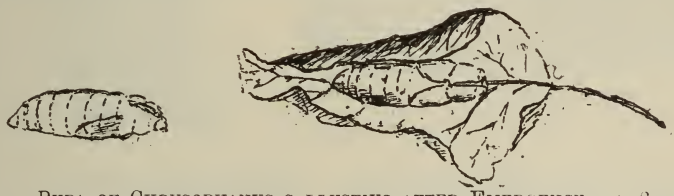
The few taken showed considerable variation, some appearing mainly green, others almost red. The sides were dull green, ornamented with oblique stripes, which varied in the different specimens from dark brick-red to pink. The hairs showed prominently, being long and numerous.

Pupa.—The pupa was about 6 mm. in length, and stout for its length. The head and thorax were pale green, the abdominal segments brick-red. A double pink line dorsally. According to my observations, no trace of the wing-markings showed through before emergence.

Chrysophanus sallustius.

Although common throughout the South Island, this butterfly does not appear to be as variable here as in the North Island. The first specimens are in flight here early in November, the last at the end of April.

When collecting near the Upper Hutt with Mr. H. Simmonds he took a single larva of this species when beating *Coprosma* for *Coleoptera*, and this larva he kindly handed over to me. It was about 12 mm. long, slug-like, bright green, with a crimson streak down the back. The caterpillar



Pupa of Chrysophanus sallustius after Emergence. × 2.

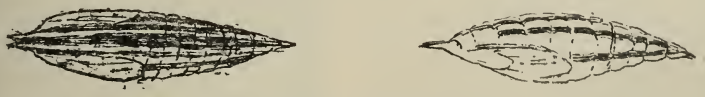
pupated in a half-curled leaf almost immediately. The pupa was pale green with a paler line down the back, and was 10 mm. in length, and stout for its length.

Argyrophenga antipodum.

This butterfly seems to be confined to the South Island, frequenting only the tussock country. Mr. Hudson, in his "New Zealand Moths and Butterflies," gives a description of the larva and pupa.

In February, 1911, when collecting near Fairlie, I was fortunate enough to secure a single fully fed larva of this species. It remained in the collecting-box for three days before I had time to further examine it, and I then found that in the interval it had changed to the chrysalis. Eight days later the butterfly emerged. The caterpillar, in shape, colouring, and markings, closely resembled the chrysalis.

Pupa.—Length, just ¾ in., but, being late in the season, this specimen was probably undersized; broad for its length; two horns tussock-colour,



Pupa of Argyrophenga antipodum. × 2.

edged with white, projected from the head, and a similar horn from the tail. A white line from front of head along thorax, then splitting into

two thin white lines to enclose a dark-greenish dorsal line. A thin red line in conjunction with a white line from tip of frontal horn to tip of tail horn. Two fainter lines from wing-cover to tip of abdomen. A white line edged both sides with red from centre of wing-case, not reaching to end of abdomen. A dark line with a white line below along the top of wings. Veins of future wings clearly outlined. As the insect neared emergence the dark spots on the wings showed plainly through the pupa skin.

Correction.

In the "Transactions of the New Zealand Institute," vol. 43, 1911, pp. 127, 128, I find I have carelessly written "lines" where it should be "mm." Unfortunately, this not only makes the description read wrongly as to the wing-expanse, but has also mislead those responsible for the reproduction of the illustrations, so that these have been printed much over their natural size.

Art. XXII.—*The Raised Beaches of Cape Turakirae.*

By B. C. Aston, F.I.C., F.C.S.

[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

Plates XIII, XIV.

Cape Turakirae is the north-western point facing Cape Palliser, the two capes enclosing that noble stretch of water known as Palliser Bay. The remarkable geological and botanical features of Turakirae hitherto appear to have escaped the attention they merit, and it is with the hope of remedying this neglect that this paper is written.

The Orongorongo River, near the mouth of which is situated Mr. Riddiford's homestead, cuts through a series of raised beaches, now more or less obscured by drifting sand or overgrown by herbage. They are, moreover, composed of finer material—mostly coarse sand—than those same beaches a mile nearer the cape. Their finer nature is accounted for by the fact that the rivers would bring down quantities of fine debris, which would be thrown up by the sea. Three beaches are here to be distinguished, and, as their altitude is the same, they are undoubtedly of the same age as those three hereafter described as being nearer the sea. The beach presumably elevated at the time of the 1855 earthquake is here very well developed. The influence of the fineness of beach-particles on the flora will be presently noticed. It is not until one has crossed the river, and proceeded a mile or so towards Palliser Bay, that the eye of the observer is arrested by the extraordinary physiographical aspect of the country lying between the track at the base of the steep hillside and the sea. The track follows a course close to the foot of the hills, about 100 ft. above sea-level, and between this and the sea is a stretch of rocky country varying from 250 to 400 yards in width, and extending some two or three miles, narrowing to nothing on the further side of the cape. This rocky plain consists mostly

[Face p. 208.]

Fig. 1.

Fig. 3.

Fig. 2.

Fig. 4.

Fig. 1.—Corynocarpus Association on Shingle Fans, Palliser Bay, looking towards Head of Bay. (Shown also in Fig. 3.)
Fig. 2.—Corynocarpus and Muehlenbeckia complexa Associations on Beach No. 4 (80 ft. above Sea), looking Seawards.
Fig. 3.—Pond formed immediately above Beach No. 2 (40 ft. above Sea), looking towards Cape Turakirae.
Fig. 4.—Beach No. 1 (9 ft. above Sea), elevated at 1855 Earthquake. Mukumuku cliffs and shingle fans in the distance.

Fig. 1.—Beach No. 5 (95 ft. above Sea).
Showing recently rolled boulders and *Corynocarpus* growing on Beach No. 4, immediately below.

Fig. 2.—Boulder Plain with No. 3 Beach (60 ft. above Sea, on Extreme Left of Photo) running through it.
The black patches on beach are *Muehlenbeckia complexa*. On extreme right of photo may be seen in the distance No. 2 Beach (40 ft. above sea).

of large boulders 3 ft. to 8 ft. in diameter, but running roughly parallel with the sea throughout the length of the boulder-strewn plain are two excellently defined shingle beaches. These stand out most conspicuously, and form natural roadways along which one may drive. For the greater part the shingle presents an appearance differing little from that of beaches which often exist now at the ocean's marge. In many places the shingle is, however, overgrown with *Muehlenbeckia complexa*, or with grasses and other plants. The main impression left on one's mind is that marvellously little alteration has taken place in the peopling of these areas by plants, and in the external appearance of the shingle generally, in the hundreds of years which have probably elapsed since each was rapidly elevated. The survival of the beaches as shingle involves the fact that it is composed of the harder portions of the country rock, and which would hence, in the equable climate, offer a considerable resistance to the weathering influences; isolated by boulder plains on all sides, little dust could blow in and form soil between the interstices, and without soil little atmospheric moisture could be retained. Only specially adapted shingle-plants, such as *Muehlenbeckia*, could, therefore, hope to survive in such a station.

Happily, we are not entirely in the dark as to the rapidity with which these beaches may be elevated beyond the reach of the breakers. It is well known that the coast at Mukumuku was elevated 9 ft. during the earthquakes of 1855 (see Crawford, Trans. N.Z. Inst., Essay, vol. 1, p. 18). Knowing this, the author carefully searched the boulder-strewn shore a little above high-water mark, and was rewarded by finding traces of a shingle beach about that altitude above high-water mark. Further search nearer Mukumuku showed a long strip of shingle beach quite as well developed as the older beaches. The fact that the sea is now breaking on boulders and monoliths somewhat discounts the thought that beach No. 1 may be a mere storm beach. Exploring the country adjacent to the hills, two much older shingle beaches were found. These nearly everywhere have been obliterated by the debris carried down by temporary creeks from the steep hillsides, the site of the older beaches being now occupied by fans of angular shingle, mixed with finer detritus, many acres in extent, which may or may not support a flora. This recent alluvium has buried these two older beaches many feet below the surface, but where fragments of them remain one is again struck with the extremely recent appearance of the beach, as Plate XIV, fig. 1, truly depicts. The interesting fact that the younger of these beaches is that more thickly populated by a flora is probably accounted for by the difference in size of the component stones, which explanation must also suffice for the fact that much of the newer fan-material supports dense formations of herbage or arboreal growth. Five distinct shingle beaches have now been mentioned, which for the sake of ease of reference may be designated by the numbers 1, 2, 3, 4, and 5, No. 1 being the youngest (the 1855) beach and No. 5 the oldest. Observations taken with a surveying aneroid show that the level of each of these beaches is practically constant along its entire length—that is to say, beach No. 1 is approximately 9 ft. (see Plate XIII, fig. 4), beach No. 2 is 40 ft., beach No. 3 is 60 ft. (see Plate XIV, fig. 2), beach No. 4 is 80 ft. (see Plate XIII, fig. 2), and beach No. 5 is 95 ft. (see Plate XIV, fig. 1) above high-water mark.

The material of which all this elevated country is composed has so far been roughly classified as boulders and shingle, but there is a third most extraordinary component, the solitary monoliths which stand out some-

times as much as 15 ft. above the surrounding country, enabling a comprehensive view of it to be obtained from their summits. There are no monoliths or disproportionately sized boulders on the beaches, with a few unimportant exceptions. Plate XIV, fig. 1, shows a few large boulders have rolled, perhaps comparatively recently, on or near beach No. 5. These monoliths are often very much undercut, and present the appearance of having rolled into the positions they now occupy, rather than of having been weathered into their present shape by wave-action. Where the sea broke at the tide-limits a shingle beach would form; above and below the tide-limits less weathering would occur. Sudden elevation would remove an area beyond reach of the waves, and as this was repeated the alternation of shingle and boulder is thus accounted for. Possibly the original relation of shore to sea-floor was that of a perpendicular or overhanging cliff with the floor projected at an obtuse angle from the base of it. Successive movements of the earth might dislodge much of the cliff-material, and build up a submarine platform. One would like to find some explanation for the fact that these rolled monoliths occur such a distance from the base of the present cliffs. It is not easy to see how faulting at the base of the cliffs can have been a factor in the uplift, as this would have to take place in a semicircular sweep round the cape, and there is plenty of evidence of recent dislodgment of large masses of rock from the hillside. Earthquakes may have played a considerable part in loosening large masses of rock. One rolled monolith examined was roughly cubical in shape, and its side measured 15 ft., its estimated weight being 250 tons.

The age of these beaches is a most fascinating theme to speculate upon. The fresh appearance of the shingle makes it hard to realize that centuries must have elapsed since they were removed beyond the reach of the tide Mr. Elsdon Best informs me of a Maori tradition which relates that the Miramar Peninsula, previously an island, was elevated about four hundred years ago to its present position, which is evidence, of a kind, of coast-elevation within historic times, prior to 1855. (See also Cotton, p. 245 of this volume.)

If the geological features of this area are intensely interesting, the botanical features are even more so. Within a few hundred yards may be found the plants of the arid rock-faces, the fresh-water swamps and ponds, the sea littoral, the grass meadows, and the forest.

Starting from the sea-shore a little above high-water mark, in a situation well moistened by sea-spray are found the usual halophytic plants, *Salicornia australis* Sol., *Samolus repens* Pers., *Triglochin striatum* var. *filifolium* Buch., *Apium prostratum* Labill., *Selliera radicans* Cav., *Scirpus nodosus* Rottb., *Carex ternaria* Forst., *Juncus effusus* Linn. These are growing between boulders 3 ft. to 4 ft. in diameter, which formation occupies some 10 or 20 yards until the shingle of beach No. 1 is reached. On this grow the beautiful *Glaucium flavum* Crantz (naturalized), *Senecio lautus* Forst., *Apium prostratum* Labill., *Poa anceps* Forst., *Calystegia soldanella* R. Br., and the naturalized *Picris echioides* Linn. and *Plantago lanceolata* Linn.

Now comes a stretch of big boulders and monoliths, amongst which are growing in very wet or very dry stations the following: *Leptocarpus simplex* A. Rich., *Mariscus ustulatus* Clarke, *Phormium Cookianum* Le Jolis, *Selliera radicans* Cav., *Raoulia australis* Hook. f., *Muehlenbeckia complexa* Meissn., *Olearia Solandri* Hook. f., *Cassinia leptophylla* R. Br., *Plagianthus divaricatus* Forst., *Hymenanthera crassifolia* Hook. f., *Arundo conspicua* Forst., *Euphorbia glauca* Forst., *Clematis Colensoi* Hook f., *Epilobium*

erectum D. Petrie, *Deyeuxia Forsteri* Kunth., *Poa anceps* Forst., *P. caespitosa*, Forst., *Myoporum* and *Coprosma Baueri* Endl. shrubs (occasionally), *Australina pusilla* Gaud., *Adiantum affine* Willd., and the naturalized *Picris echioides* Linn., *Nasturtium officinale* R. Br., *Myosotis palustris* Linn. Parts of this rockery may not be so wet, and may then contain *Leptospermum scoparium* Forst., *L. ericoides* A. Rich., *Coprosma rhamnoides* A. Cunn., *C. robusta* Raoul, *C. parviflora* Hook. f., *Pimelea laevigata* Gaertn., *Olearia Cunninghamii* Hook. f., and a sward of introduced *Medicago lupulina* Linn., and *Hypochaeris radicata* Linn., and some *Caucalis nodosa* Scop., *Cnicus lanceolatus* Willd., *Rosa rubiginosa* Linn. occurs.

This boulder terrace occupies a width of from 50 to 150 yards, and at the further side of it an abrupt rise consisting of shingle is encountered. This is beach No. 2, and growing on it is often a sward of naturalized *Rumex acetosella* Linn., *Lolium perenne* Linn., *Festuca myuros* Linn., *Hordeum murinum* Linn., and *Erodium cicutarium* L'Herit., or a thicket of *Silybum Marianum* Gaertn.; while the native plants present are *Muehlenbeckia complexa* Meissn., *Aciphylla squarrosa* Forst., *Hymenanthera crassifolia* Hook f., *Bulbinella Hookeri* Benth., *Plagianthus divaricatus* Forst., *Olearia Solandri* Hook f., *Coprosma propinqua* A. Cunn. At the Orongorongo River, where the beach is composed of coarse sand, it is almost covered in parts with the beautiful silvery *Raoulia australis* Hook f., with *Zoysia pungens* Willd. growing through it. Near Mukumuku Stream this plant covers a sandhill some 30 ft. high, which can easily be picked out by its colour some three miles away.

Towards the north-east end of these beaches, on the landward side, just above No. 2 beach, are two ponds. The vegetation surrounding and growing in the larger of these presents considerable contrasts. On the dry shingle of the beach characteristic rounded clumps of *Muehlenbeckia complexa* Meissn. dominate that position. In wet ground, nearer the pond, *Mariscus ustulatus* Clarke abounds. Nearer still is *Eleocharis acuta* R. Br. and plants of *Rumex crispus* Linn. (natd.). The entire margin of the pond is fringed with a yellow *Conferva*, and the whole of the pond itself is filled with a dense dark-red growth of *Myriophyllum elatinoides* Gaud. and a little *Potamogeton Cheesemanii* Bennett. The landward shore of the pond is covered by *Eleocharis* and *Typha angustifolia* Linn., with some *Leptocarpus simplex* A. Rich., *Scirpus lacustris* Linn., *Juncus effusus* Linn., *Cladium junceum* R. Br., *Phormium tenax* Forst., *Carex ternaria* Forst., *Calystegia tuguriorum* R. Br. The naturalized *Nasturtium officinale* R. Br. and *Myosotis palustris* Lam. also occur in considerable quantity. In the dry boulder-bank or in boggy places above are to be found the rare *Sebaea ovata* R. Br. (a yellow-flowered gentianous plant now for the first time recorded from Wellington Province), *Potentilla anserina* Linn., *Pelargonium australe* Jacq., *Geranium molle* Linn., *Hydrocotyle asiatica* Linn., *Vittadinia australis* A. Rich., *Gnaphalium collinum* Labill., *Craspedia uniflora* Forst., *Festuca multinodis* Hack., *Microtis parvifolia* R. Br., *Linum monogynum* Forst., *Epilobium Billardieranum* Ser., *Ranunculus hirtus* Banks & Sol., *Samolus repens* Pers., *Galium umbrosum* Sol., *Euphrasia cuneata* Forst., *Haloragis alata* Jacq., *H. depressa* Walp., *Lagenophora pumila* Cheesm., *Ranunculus rivularis* Banks & Sol., *Dichelachne crinita* Hook. f., and the naturalized *Silene gallica* Linn., *Briza maxima* Linn., *Cyperus vegetus* Willd., *Vicia* sp. Near Orongorongo Stream *Eryngium vesiculosum* Labill. occurs plentifully above the beach. In the centre of the stony plain, clustering round the monoliths on the upper edge of beach

No. 2, is to be found a little forest, consisting of *Corynocarpus* (sometimes 18 in. in circumference), *Melicytus ramiflorus* Forst., *Myrsine Urvillei* A. D. C., *Coprosma Cunninghamii* Hook f., *Panax arboreum* Forst., *Cordyline australis* Hook. f., *Piper excelsum* Forst., *Coriaria ruscifolia* Linn., *Asplenium lucidum* Forst., *Coprosma Baueri* Endl., *Olearia Cunninghamii* Hook. f., *Pellaea rotundifolium* Hook. f. On beach No. 3 flourish most of the plants mentioned as found on No. 2. *Muehlenbeckia complexa* Meissn. is the most characteristic on this beach, which is the best developed of the five described. *Danthonia semiannularis* R. Br., and the naturalized *Polycarpon tetraphyllum* Linn., *Poa pratensis* Linn., and *Bromus mollis* Linn. also occur.

The next strip of boulder terrace, between beach No. 3 and beach No. 4, is most interesting for the number and variety of species it contains. Some portions consist of boulders 5 ft. to 8 ft. in diameter, and fairly uniform in size, and growing among them are *Phormium Cookianum* Le Jolis, *P. tenax* Forst., *Dichondra repens* Forst., *Epilobium insulare* Haussk., *Hymenanthera crassifolia* Hook. f., *Mariscus ustulatus* Clarke, *Hydrocotyle asiatica* Linn., *H. novae-zelandiae*, *Dichelachne crinita* Hook. f., *Carex ternaria* Forst., *Astelia nervosa* Banks & Sol., *Cordyline australis* Hook f., *Leptospermum scoparium* Forst., *Olearia Solandri* Hook f., *Scirpus prolifer* Rottb., *Drosera binata* Labill., and the naturalized *Ranunculus acris* Linn. and *Myosotis palustris* Lam. are common. Extensive *Phormium* and *Typha angustifolia* Linn. swamps occur, which also contain *Juncus caespiticius*, *J. prismatocarpus* R. Br., *J. bufonius* Linn., *J. vaginatus* R. Br., *Schoenus axillaris* Poir., and ponds may form. In this area occur most of the monoliths, the flora of which is utterly distinct from that of the swamp, pond, or damper ground immediately below them. The most remarkable constituent of the monoliths' flora is *Dendrobium Cunninghamii*, which is growing as a thick sward 6 in. or 7 in. high, and fully exposed to the wind and sun, a fact first noticed by Colenso in this very spot (see "First Journey to the Ruahine Range," p. 11). Four other epiphytic orchids are growing on the rock-faces—*Sarcochilus adversus* Hook. f., *Bulbophyllum pygmaeum* Lindl., *Earina mucronata* Lindl., and *E. suaveolens* Lindl.—and yellow clumps of *Scleranthus biflorus* Hook. f., the climbing *Polypodium serpens* Forst., and *Mesembryanthemum australe* Sol. In chasms or small clefts or on the tops some soil has formed, and here are to be found *Coprosma Baueri* Endl., *Hymenanthera crassifolia* Hook. f., *Arthropodium candidum* Raoul, *Helichrysum filicaule* Hook. f., *Agropyrum scabrum* Beauv., *Craspedia uniflora* Forst., *Clematis Colensoi* Hook. f., *Luzula campestris* D. C., *Festuca multinodis* Hack., *Poa anceps* Forst., *Danthonia semiannularis* R. Br., *Pimelea laevigata* Gaertn., *Linum monogynum* Forst., *Trisetum antarcticum* Prin., *Tillaea Sieberiana* Schultz, *Aciphylla squarrosa* Forst., *Rhagodia nutans* R. Br., *Thelymitra longifolia* Forst., *Dichondra repens* Forst., *Asplenium flabellifolium* Cav., *Metrosideros robusta* A. Cunn. may even occur.

Above beach No. 3, in wet parts, occur *Cotula coronopifolia* var. *integrifolia* Linn., *Ranunculus rivularis* Banks & Sol., *Eleocharis Cunninghamii* Boeck., *Juncus pallidus* R. Br., *J. maritimus* Lam., *J. lampocarpus* Ehr., *Carex virgata* Sol., *C. lucida* Boott., *Azolla rubra* R. Br., *Lobelia anceps* Linn. f., *Nertera depressa* Banks & Sol.; and in the drier parts *Olearia Forsteri* Hook. f., *Prasophyllum Colensoi* Hook. f., *Urtica ferox* Forst., *Calystegia sepium* R. Br., *Apium prostratum* var. *filiforme* Labill., *Rubus cissoides* A. Cunn., *Lomaria capensis* Willd., and the naturalized *Lythrum hyssopifolium* Linn., *Sherardia arvensis* Linn., *Bromus sterilis* Linn.

On beach No. 4, in places, true forest is found. This is nearly a pure *Corynocarpus* association. Some of the trees are very old, measuring up to 6 ft. in circumference, and may be two hundred years old. Plate XIV, fig. 1, shows No. 5 beach with one quick-growing tree, *Myoporum laetum* Forst., on it; but the *Corynocarpus* is confined to No. 4 beach, immediately below and contiguous to No. 5 beach. Where *Corynocarpus* has not established itself on No. 4, *Muehlenbeckia complexa* Meissn. covers the beach (see Plate XIII, fig. 2). On the slopes of it grow a charming shrubbery of *Pennantia corymbosa* Forst., *Melicope ternata* Forst., *Myoporum laetum* Forst., *Sophora tetraptera* J. Mull., *Pittosporum tenuifolium* Banks & Sol., *Parsonsia heterophylla* A. Cunn., *Passiflora tetrandra* Banks & Sol., *Cordyline australis* Hook f., *Clematis Colensoi* Hook. f., *Piper excelsum* Forst., among the herbaceous plants being *Parietaria debilis* Forst., *Wahlenbergia gracilis* A. D. C., *W. saxicola* A. D. C., and the naturalized *Fumaria muralis* Sond.

On beach No. 5 an unusual sight is *Muehlenbeckia australis* Meissn. adopting the habit and station affected by its congener *M. complexa* Meissn., and scrambling over the horizontal stones, instead of climbing over trees in its usual manner.

The flora of the fans which have covered up so much of the two oldest beaches may be briefly described. The oldest material supports pure woods of *Corynocarpus* (karaka), often with a pure fringing wood of *Myoporum*. Plate XIII, fig. 1, shows a good example of a karaka grove. The action of the wind in bunching the topmost leaves and branchlets together at the southern, seaward, and exposed extremity of the grove, while they regain their normal habit as they approach the hills, is most instructive. The younger alluvium supports a dense sward of indigenous *Danthonia pilosa* R. Br. and *Microlaena stipoides* R. Br., and naturalized grasses and clovers. The youngest fan-material grows chiefly the naturalized thistles *Cnicus lanceolatus* Willd. and *Silybum Marianum* Gaertn., the latter often impenetrable thickets acres in extent. Reference must be made to that remarkable new species, *Muehlenbeckia Astoni* Petrie (figured in Trans. N.Z. Inst., vol. 43, p. 257). This rare plant grows on the talus slopes and shingle fans. It is remarkable for the regularity of the angle of branching (approximately 120 degrees) and for the fact that it is the only New Zealand species with an erect habit of growth.

The author, who has made twelve visits to the cape altogether, desires to express his grateful acknowledgments for the support he has received from Professor Easterfield, Dr. D. Petrie, Messrs. T. F. Cheeseman, J. S. Tennant, E. Phillips Turner, P. Freyberg, and his brothers (C. G., Cyril, and W. B. Aston), who have all accompanied him in these lengthy walks at various dates during the last four years.

Summary.

The raised marine beaches at Cape Turakirae show that there has occurred comparatively recently, and perhaps within historic times, rapid elevation of the coast-line near Palliser Bay at least four times prior to the sudden elevation of 9 ft. which took place in 1855. Violent earth-movements have so altered the physiography of the littoral as to result in some unusual ecological features.

Art. XXIII.—*The Geographic Relationships of the Birds of Lord Howe, Norfolk, and the Kermadec Islands.*

By W. R. B. Oliver.

[*Read before the Auckland Institute, 28th November, 1911.*]

Whether the main islands of New Zealand, together with certain outlying islands, be considered entitled to the full rank of biological "region," or only that of "subregion," will not affect the contention which the evidence assembled in this paper is held to support—namely, that the three groups of islands lying to the north of New Zealand (Lord Howe, Norfolk, and the Kermadecs) should be included within that region. It can be said that conclusions drawn from the study of one class of animals may not be trustworthy, and should be checked by conclusions deduced from a consideration of other classes. There can be no questioning the truth of this statement, and I would go even further, and say that the claims of a district on the border-line of two biological regions to be included in any one of such regions should be decided upon an examination of the whole of the fauna and flora of the district in question, together with a consideration of its geological history. In most cases this is not practicable, and in this paper I will deal principally with the avifauna of Lord Howe, Norfolk, and the Kermadec Islands, only referring incidentally to other sections of the fauna or to the flora, and endeavour to point out its true relationship to those of the adjacent biological regions.

In treating of islands, the real test for deciding to which region they should be attached is to consider the evidence in favour of a land connection with a part of the region within the bounds of which it is claimed they should be included. If the probabilities are that the islands have never been actually joined to a land-mass, then the character of the fauna and flora must decide. But here certain life-forms, such as pelagic species, need not be taken into account, except as characterizing a province or subregion. Again, the presence of such a group as "accidental visitors" may be due merely to climatic conditions, and cannot be held to ally one fauna to another any more than the occasional occurrence of a stray royal spoonbill or pelican in New Zealand allies the avifauna of that country to that of Australia, for species of birds cannot often be dispersed by such accidents.

From a geographical standpoint, the birds of a district may be arranged according to their life-forms or manner of occurrence into groups. The ecological groups into which I have divided the birds of Lord Howe, Norfolk, and the Kermadec Islands, and whose numerical strength in these islands is shown in the following table, would not necessarily be the most useful to adopt when treating the avifauna of a large area, but are, I think, the most convenient for the purpose of this paper.

Ecological Group.	Lord Howe.	Norfolk.	Kermadecs.
Resident land-birds—Breeding ...	15	19	6
Sea-birds—Breeding	8	11	12
Visitors—			
Sea-birds	6	5	10
Migrants	11	7	8
Occasional	13	6	4
Accidental	8	5	3
Totals	61	53	43

Resident land-birds are the most important from a geographical point of view, as they alone include species whose presence can only be accounted for by a former land connection. The group sea-birds includes forms which habitually frequent the open sea, but does not include coastal genera, such as *Larus* and *Phalacrocorax*. Those breeding in the islands are chiefly circumtropical species, and of no value in determining the geographic relationships of the avifauna, as their presence depends mainly on the latitude of the place. Migrants, especially if occurring regularly and in large numbers, are important as indicating the line of a former land connection.* Occasional visitors are those which regularly visit the islands, or have frequently been recorded. They probably belong to species which are in the habit of wandering far from their ordinary breeding-places, and possibly frequently cross and recross the Tasman Sea. Most of them are fairly widely distributed, ranging from the Malay Archipelago through Australia to New Zealand. Accidental visitors are stragglers (and I have included doubtful records under this heading).

I wish here to acknowledge my indebtedness to Mr. Basset Hull's valuable paper on the "Birds of Lord Howe and Norfolk Islands,"† from which, mainly, the list of birds inhabiting those islands, together with other information, have been taken. By searching through the British Museum "Catalogue of Birds" I have added a number of other records, and the lists have been added to from other sources. In the list of birds of the Kermadec Islands there appear the names of six species not hitherto recorded from the group—*Prion desolatus*, *Sterna bergii*, *Tringa canutus*, *Oestrelata macroptera*, *Sula leucogaster*, *Phalacrocorax sulcirostris*. For three of these I have to thank Mr. T. F. Cheeseman, F.L.S., who kindly supplied me with a list of the skins in the Auckland Museum collected by Mr. R. S. Bell on Sunday Island. Of the fourth—*Oestrelata macroptera*—dead specimens were found by myself in 1908 washed up on the beach in Denham Bay, Sunday Island. A dead specimen of *Sula leucogaster* was found on the beach in Denham Bay by Mr. R. S. Bell previous to my visit, and the same observer states that a small number of *Phalacrocorax sulcirostris* once made their abode on Sunday and Macaulay Islands, staying for some years. They, however, failed to establish themselves.

Lord Howe Island.

Of fifteen species of resident land-birds breeding in the island, twelve (including *Aplonis fuscus*, which occurs also on Norfolk Island) are endemic. The affinities of the peculiar forms are mainly with New Zealand and New Caledonia. Species related to New Zealand forms are *Nesolimnas sylvestris*, *Notornis alba*, and *Cyanorhamphus subflavescens;* those related to New Caledonian forms are *Turdus vinitincta* and *Aplonis fuscus*. The two species of *Gerygone* are allied to forms in New Zealand and New Caledonia, while the Lord Howe and Norfolk Island species of *Zosterops* belong to a group occurring in New Zealand, New Caledonia and adjacent islands, and Australia. The remaining three endemic species—*Ninox albaria*, *Rhipidura cervina*, *Pachycephala contempta*—are probably related to Australian forms. Numerically the Australian, New Zealand, and New Caledonian elements in the endemic birds of Lord Howe Island are about equal, or overwhelmingly in favour of a New

* Hutton, Trans. N.Z. Inst., vol. 5, p. 235.
† Proc. Linn. Soc. N.S.W., vol. 34, p. 636.

Caledonia – New Zealand migration as against an Australian immigration. The two flightless rails turn the balance in favour of New Zealand. The distribution of the three resident land-birds not peculiar to Lord Howe Island shows but a slight excess of Australian immigrants over others. *Strepera graculina* extends to Australia, *Halcyon vagans* to New Zealand, while *Chalcophaps chrysochlora* (perhaps introduced) is found in Australia and New Caledonia.

Eleven migrants have been recorded from Lord Howe Island, some of which occur regularly in considerable numbers. Two are cuckoos, the rest Charadriiformes; all have been recorded in New Zealand, and all except *Eudynamys taitensis* in Australia. It is evident that the island is in the line taken by these species on their migration to and from New Zealand, and thus probably on an old land-line stretching northwards from New Zealand.

Of the thirteen occasional visitors which have been recorded in Lord Howe Island, all are found in Australia, ten extend to New Zealand, and eleven to New Caledonia or Malaya. The proximity of the Australian Continent to Lord Howe Island and the direction of the prevailing winds (westerly) in the south-west Pacific is sufficient to account for the preponderance of Australian forms in the accidental visitors to the island. Of the eight recorded, only two extend to New Zealand.

The large proportion of endemic forms in the resident land-birds of Lord Howe Island points to the long period the island has been an isolated spot. The existence of two brevipinnate rails belonging to genera found elsewhere only in New Zealand is sufficient proof of a former land connection with that country. That there was also land connection to the north, whence these birds probably came, is indicated by the large proportion of endemic Lord Howe Island land-birds which are allied to New Caledonian forms. Corroborative evidence of a land bridge between New Caledonia and New Zealand is furnished by the presence in Lord Howe Island of the large land-mollusc *Placostylus*.* It would be over this bridge that the large portion of the New Zealand fauna and flora showing Malayan affinities migrated. As the two flightless rails mentioned above are closely allied to New Zealand forms, it is probable that the land bridge was severed in the north before the connection with New Zealand was broken. Lord Howe Island would therefore properly belong to the New Zealand biological region. Australia can have no claim whatever to include Lord Howe Island within its regional limits, as a permanent ocean-basin separates the island and continent, and what birds of Australian origin are found in Lord Howe Island have crossed the intervening tract of ocean, yet in spite of the proximity of the continent have not outnumbered the New Caledonian and New Zealand forms except in those groups which I have designated occasional and accidental visitors.

Norfolk Island.

There are twelve endemic species of land-birds (including *Aplonis fuscus*). Of these, four—*Hemiphaga spadicea, Nestor productus, Cyanorhamphus cooki, Gerygone modesta*—are related to New Zealand species; two — *Rhipidura pelzelni, Pachycephala xanthoprocta* — to Australian species; four—*Petroica multicolor, Diaphoropterus leucopygius, Turdus fuliginosus, Aplonis fuscus*—to New Caledonian species; and there are two species of *Zosterops*. Numerically the New Caledonian element pre-

* Hedley, Proc. Linn. Soc. N.S.W., vol. 7 (1892), p. 335.

dominates, and, as with Lord Howe Island, the species of this and the New Zealand element together far outnumber those of the Australian section; but again the presence of such important genera as *Nestor* and *Hemiphaga* turns the scale in favour of New Zealand. Of the seven resident land-birds not peculiar to the island, one—*Halcyon vagans*—extends to New Zealand; two—*Platycercus elegans* (perhaps introduced), *Ninox boobook*—to Australia; while the remaining four are found in both these countries. Australian forms are thus scarcely in excess of others.

The migrants recorded include the same two species of cuckoo as occur in Lord Howe Island, and five Charadriiformes, two of which are said to be plentiful at certain seasons of the year. Here again an old land-line is indicated.

All the occasional visitors to Norfolk Island occur in both Australia and New Zealand. Of the five accidental visitors, all are Australian forms, of which three have been recorded from New Zealand as stragglers, and one—*Herodias timoriensis*—is resident there.

There are no species of birds in Norfolk Island whose presence demands that the island should at one time have been connected with a large land-area; nor, as far as I am aware, are there any other members of the indigenous fauna or flora of the island whose presence cannot reasonably be attributed to dispersal by their own means or by accident across a narrow sea. At the same time, as the avifauna shows similar characteristics to that of Lord Howe Island—namely, by its large proportion of endemic land-birds and strong New Caledonian – New Zealand affinities—it is evident that both islands received their first land-birds about the same time and by the same route. It seems most probable that at the time Lord Howe Island was actually part of the land bridge stretching northwards from New Zealand, Norfolk Island was a detached islet lying off the east coast of the land, and thus received its fauna and flora across a narrow strait. The present contour of the ocean-floor lends support to this view, as Norfolk Island is completely surrounded by deep water—over 1,000 fathoms—while Lord Howe Island lies in comparatively shallow water on the western edge of a submarine ridge stretching from New Zealand to New Caledonia. For reasons of like origin and characteristics the avifaunas of Lord Howe and Norfolk Islands proclaim that both islands must be included in the same biological region, and their relationships as detailed above decide this to be the New Zealand region.

Kermadec Islands.

The conspicuous feature of the avifauna of the Kermadecs is its paucity of land-birds, and what few occur there are of a decided New Zealand character. There is practically no Australian element represented.

The migrants include the two cuckoos mentioned above as occurring in Lord Howe and Norfolk Islands, and six Charadriiformes. None occur in any great numbers; thus their presence affords but little indication of the island lying in an ancient land-line. If a large area of land ever existed in this direction, it disappeared before the present islands came into existence.* The occasional and accidental visitors are all common New Zealand species, and all except *Anthus novae-zealandiae* occur also in Australia.

The Kermadec Islands are of a typical oceanic character—that is, they were formed by volcanic action in mid-ocean, and have been populated

* Trans. N.Z. Inst., vol. 20, p. 161; vol. 43, p. 531.

entirely by trans-oceanic migration. The land avifauna and flora are unmistakably closely allied to those of New Zealand, so that the islands fall naturally within the New Zealand biological region. The marine fauna has affinities with that of Polynesia. An explanation of this meeting of New Zealand land species and Polynesian marine species may lie in the fact that during the winter months, which cover the period when plant-seeds are being dispersed, the prevailing winds in the Kermadecs are from the south-west, while during the summer months, when the free-swimming larval forms of marine animals are abundant, the prevailing winds are from the north-east.

The Lord Howe – Norfolk Island Province and the Kermadec Islands Province.

Having shown by an analysis of their avifaunas that Lord Howe, Norfolk, and the Kermadec Islands fall within the limits of the New Zealand biological region, it remains only to consider whether they form one or more provinces or subregions of that region.

The avifaunas of Lord Howe and Norfolk Islands are undoubtedly closely allied. Of the resident land-birds two species are common, to which must be added the endemic species of four genera — *Gerygone*, *Cyanorhamphus*, *Turdus*, *Zosterops*—having representative forms in each island. Most of the sea-birds (breeding), migrants, and occasional visitors are common to the two islands, but, from the manner of their occurrence, this is not the case with the accidental visitors and the sea-birds (visitors).

With regard to the six resident land-birds of the Kermadec Islands, all except *Prosthemadera novae-zealandiae* are identical with or closely allied to species in Norfolk Island or Lord Howe Island. But of resident land-birds in Lord Howe or Norfolk Islands found also in the Kermadecs the proportion is very low, so that the fact that five-sixths of the Kermadec land-birds are related to species found in Lord Howe and Norfolk Islands merely shows that in all probability, as with the plants, some of the species in the Kermadecs which occur in both New Zealand and Norfolk Island have arrived from Norfolk Island direct. The sea-birds (breeding) and migrants chiefly belong to the same species as occur in Lord Howe and Norfolk Islands. The occasional and accidental visitors, like the resident land-birds, are very few, a fact which can be explained by the isolated position of the islands.

The three islands therefore fall naturally into two biological provinces. One includes Lord Howe and Norfolk Islands, and is characterized by an avifauna containing four main elements: (1) an original element which includes the species which came by the ancient New Caledonia – New Zealand land bridge (majority of resident land-birds); (2) Australian and New Zealand species arrived subsequently by trans-oceanic migration (some of the resident land-birds and all the visitors except migrants); (3) circumtropical species (sea-birds, breeding); (4) migrants. The Kermadec province contains only — (1) New Zealand (and Norfolk Island) species arrived by trans-oceanic migration; (2) circumtropical species (sea-birds, breeding); (3) migrants. Although the important and characteristic element circumtropical species is common to the three islands, and, in the case of plants, formed the basis of my subtropical islands province,* I think now, on a consideration of the avifauna, that a more

* Trans. N.Z. Inst., vol. 42, p. 155.

natural arrangement is to keep the Kermadec Islands separate from Lord Howe and Norfolk Islands. The two avifaunas (and floras) will thus be grouped naturally according to their origin and characteristics.

The following is a list of species of birds arranged in groups according to their manner of occurrence :—

Lord Howe Island.

Resident Land-birds—Breeding.

Chalcophaps chrysochlora.
Nesolimnas sylvestris.
Notornis alba.
Ninox albaria.
Cyanorhamphus subflavescens.
Halcyon vagans.
Gerygone thorpei.
G. insularis.
Rhipidura cervina.
Turdus vinitincta.
Pachycephala contempta.
Zosterops tephropleura.
Z. strenua.
Aplonis fuscus.
Strepera graculina.

Sea-birds—Breeding.

Puffinus sphenurus.
P. carneipes.
Oestrelata montana.
Sterna fuliginosa.
Procelsterna cinerea.
Anous stolidus.
Sula cyanops.
Phaethon rubricauda.

Visitors—Sea-birds.

Majaqueus aequinoctialis.
Prion desolatus.
Anous leucocapillus.
Fregata ariel.
Phaethon lepturus.
Sula leucogaster.

Visitors—Migrants.

Arenaria interpres.
Charadrius dominicus.
Numenius variegatus.
N. cyanopus.
Erolia aurita.
E. ferruginea.
Limosa novae-zealandiae.
Tringa canutus.
Gallinago australis.
Chalcococcyx lucidus.
Eudynamys taitensis.

Visitors—Occasional.

Porphyrio melanonotus.
Charadrius bicinctus.
Notophoyx novae-hollandiae.
Nycticorax caledonicus.
Anas superciliosa.
Phalacrocorax sulcirostris.
P. melanoleucas.
Circus gouldi.
Eurystomus pacificus.
Cuculus inornatus.
Cacomantis rufulus.
Coracina robusta.
Grallina picata.

Visitors—Accidental.

Phaps elegans.
Himantopus leucocephalus.
Herodias timoriensis.
Ardetta pusilla.
Astur novae-hollandiae.
Haliaetus leucogaster.
Haliastur sphenurus.
Chelidon neoxena.

Norfolk Island.

Resident Land-birds—Breeding.

Hemiphaga spadicea.
Hypotaenidia philippensis.
Porzana plumbea.
Porphyrio melanonotus.
Ninox boobook.
Nestor productus.
Platycercus elegans.
Cyanorhamphus cooki.
Halcyon vagans.
Petroica multicolor.
Gerygone modesta.
Rhipidura pelzelni.
Diaphoropterus leucopygius.
Turdus fuliginosus.
Pachycephala xanthoprocta.
Zosterops caerulescens.
Z. albigularis.
Z. tenuirostris.
Aplonis fuscus.

Sea-birds—Breeding.

Puffinus sphenurus.
P. assimilis.
P. griseus.
Oestrelata philippi.
Sterna fuliginosa.
Procelsterna cinerea.
Anous stolidus.
A. leucocephalus.
Gygis alba.
Sula cyanops.
Phaethon rubricauda.

Visitors—Sea-birds.

Oestrelata macroptera.
Puffinus cerneipes.
Megalestris antarctica.
Sterna albistriata.
Ossifraga gigantea.

Visitors—Migrants.

Arenaria interpres.
Charadrius dominicus.
Numenius variegatus.
Glottis nebularius.
Limosa novae-zealandiae.
Chalcococcyx lucidus.
Eudynamys taitensis.

Visitors—Occasional.

Charadrius bicinctus.
Notophoyx novae-hollandiae.
Anas superciliosa.
Phalacrocorax sulcirostris.
Eurystomus pacificus.
Circus gouldi.

Visitors—Accidental.

Himantopus leucocephalus.
Platalea regia.
Herodias timoriensis.
Larus novae-hollandiae.
Astur approximans.

Kermadec Islands.

Resident Land-birds—Breeding.

Prosthemadera novae-zealandiae.
Halcyon vagans.
Cyanorhamphus cyanurus.
Anas superciliosa.
Porzana plumbea.
? Hemiphaga novae-zealandiae.

Sea-birds—Breeding.

Sterna fuliginosa.
Gygis alba.
Anous leucocapillus.
Procelsterna cinerea.
Phaethon rubricauda.
Sula cyanops.
Puffinus sphenurus.
P. assimilis.
Oestrelata cervicalis.
O. neglecta.
O. nigripennis.

Visitors—Sea-birds.

Daption capensis.
Diomedea exulans.
D. melanophrys.
Phoebetria fuliginosa.
Pelagodroma marina.
Sula leucogaster.
Puffinus tenuirostris.
Fregata aquila.
Prion desolatus.
Oestrelata macroptera.
Sterna bergii.

Visitors—Migrants.

Charadrius dominicus.
C. veredus.
Tringa canutus.
Numenius variegatus.
Erolia aurita.
Limosa novae-zealandiae.
Chalcococcyx lucidus.
Eudynamys taitensis.

Visitors—Occasional.

Circus gouldi.
Zosterops caerulescens.
Anthus novae-zealandiae.
Phalacrocorax sulcirostris.

Visitors—Accidental.

Hypotaenidia philippensis.
Porphyrio melanonotus.
Demiegretta sacra.

Art. XXIV.—*A Preliminary Account of the Lower Waipara Gorge.*

By R. Speight, M.Sc., F.G.S.

[*Read before the Philosophical Institute of Canterbury, 6th December, 1911.*]

Although the various localities of North Canterbury where Cretaceous and Tertiary rocks occur, such as the Middle Waipara, Weka Pass, Motunau, Omihi, and the Okuku, have received most careful attention, and have been fully dealt with on different occasions by the officers of the Geological Survey, by Haast, Hutton, and Park, and latterly by Marshall, Cotton, and the present writer, the district at the mouth of the Waipara River has hardly been noticed. Except the very brief mention of its structure by Hector (Geological Reports, 1868–69, p. x) and by Haast ("Geology of Canterbury and Westland," pp. 316–17), the published matter dealing with it consists merely of the list of fossils collected by Buchanan and Haast, referred to by Hutton in his report on the "Geology of the North-east Portion of the South Island" (Geological Survey Report, 1873–74, p. 52) and in his various publications dealing with our Tertiary series and its fossil-content, and the list given by Haast in his "Geology of

Canterbury and Westland,'' pp. 319–22. This is, as far as I have been able to glean, the total reference in published reports to this interesting locality. The present account is necessarily imperfect, but it is based on work done on numerous visits, on two of which I was fortunate in having the advice and assistance of Dr. Marshall, to whom, as well as to Mr. Suter for valuable help in identifying the fossils, my sincere thanks are due.

General Description of the Locality.

(See map.)

The district referred to in this account lies, roughly, to the south-east of the point where the railway running north from Christchurch crosses the Waipara River, and for the purposes of more accurate definition the lower gorge of the river may be taken as that part of its course which lies between its junction with the Omihi Creek and the sea. The creek joins the river about two miles below the railway-crossing, and is historically important, since it flows from the swamp where Haast obtained his Glenmark collection of moa-remains. The actual length of the gorge is about four miles. Its sides are moderately steep, easily climbed in most places, but unscalable in parts, and rising to an average height of about 350 ft. above the river-bed. They are higher on the eastern side, whence they extend as a stretch of irregular downs towards the slopes of Mount Cass, which forms the south-western buttress of the Limestone Range. On the western side of the river the banks are not so high, and they form part of the low downs stretching to the south-west towards Amberley. The breadth of the gorge varies, but it usually presents a wide floor covered with shingle, on which the river wanders. At times, however, its breadth is reduced to about 100 yards, or even less, and then the river-channel is more definitely fixed. In some places the stream forms well-defined loops or meanders—a notable one occurs about half-way through the gorge—and it is now destroying the spurs which project laterally from the high banks into these loops. Although the stream has considerable fall, the large amount of detrital matter which it transports from higher levels, and specially from the banks of loose shingle bordering its course through the Waipara Plains, has so diminished its power of erosion that it has apparently reached a temporary base-level, and this in spite of the fact that within fairly recent times—certainly since the Pleistocene—the coast has experienced a distinct upward movement.

A recent upward movement of the coast-line to the north of the Waipara has been recorded by McKay at Amuri Bluff (Report of the Geological Survey, 1874–76, p. 177), where beaches with Recent shells are found at a height of 500 ft. Evidence of the same movement at the mouth of the Conway and at Motunau is given by Hutton (Report of the Geological Survey, 1873–74, p. 54), where the land has certainly risen 150 ft., and, judging from the features of the remarkable plain of marine denudation noted by Hutton and examined more recently by the present author, the elevation has in all probability been much greater. Remnants of this plain over a mile in breadth are to be found on both sides of the mouth of the Waipara River. A little way back from the present beach is an old sea-cliff about 50 ft. high extending along the coast for several miles, and from the summit of this the land slopes gently back for about a mile, the upturned edges of the beds forming the solid substratum of the country being planed off neatly by the former action of the sea and then covered with a thin veneer of loose shingle, some of it

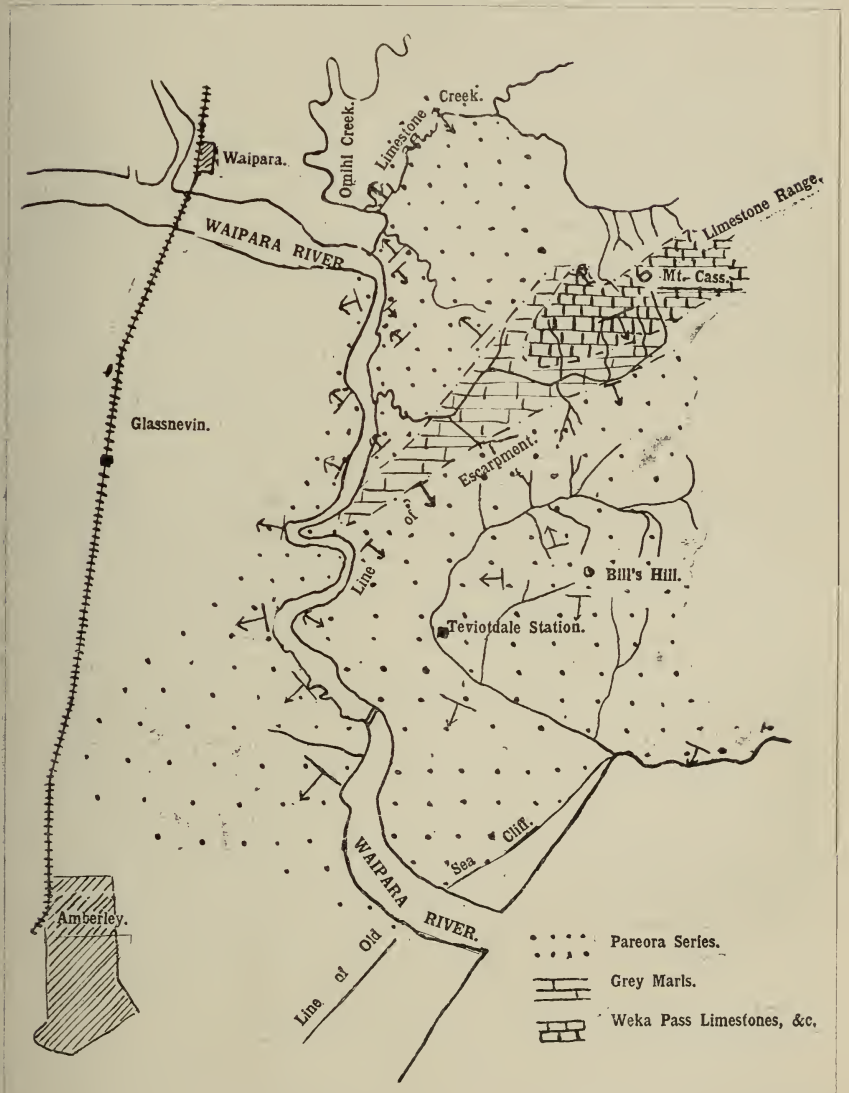

Waipara.
Omihi Creek.
Limestone Creek.
WAIPARA RIVER
Limestone Range.
Mt. Cass.
Glassnevin.
Escarpment.
Line of
Bill's Hill.
Teviotdale Station.
Sea Cliff.
WAIPARA RIVER.
Amberley.
Line of Old
Pareora Series.
Grey Marls.
Weka Pass Limestones, &c.
Geological Sketch Map
OF THE
LOWER WAIPARA DISTRICT.
1 2 3 4
Scale in Miles.

FIG. 1.

of marine origin, and of material which closely resembles the loess of the south-eastern portion of the South Island. This plain slopes back to the base of the low downs near Amberley, where it reaches a height of about 150 ft. However, on looking up the coast to the north from the mouth of the Waipara, decided remnants of a shore platform can be seen at an estimated height of 250 ft. above the sea, and fronting the plain there are several small remnants at lower levels marking stationary periods during the prolonged elevation. It is therefore certain that a long stretch of coast-line has experienced the effect of this movement. That the rise is of recent date is very clear from the species of shells found at Motunau, and also from the forms of the stream-valleys that have been established on the elevated marine shelf. With few exceptions, the streams which run across it have very short courses, and are little more than extended gullies or washouts. Through the somewhat loose Motunau marls, which form the solid base of the land, they have eroded deep channels, at times over 100 ft. in depth, extremely narrow, and with sides so precipitous that they are absolutely impassable for long distances. The whole plain is dissected by them, and they render communication a matter of difficulty where roads and tracks do not exist. The district furnishes a most remarkable example of the effect of a recent upward land-movement on the gradient and cross-section of the stream-channels. The phenomenon is intensified by the uniform seaward dip at moderate angles of the beds under the plain, and the parallelism of the strike to the coast-line. A similar phenomenon is to be observed near the mouth of the Waipara, but the features are not quite so perfect.

This plain of marine denudation once extended much further seaward, and the small island at Motunau is a remnant of it, its flat top showing a marked alignment of its surface with that of the coast-line opposite. How far this plain extended seawards it is impossible to say at present, but at the mouth of the Waipara the river-terraces appear high above the present level of the water, and are terminated suddenly when they reach the edge of the old marine cliff which marks the edge of the coastal plain. At a former period the river must have extended much further seaward, and flowed on the top of the plain, the terraces with their shorn ends giving positive proof of its higher level and seaward extension at that level. As river erosion was proceeding the sea was eating back the margin of the plain, thus giving the streams a steeper gradient and increasing their erosive power, and the truncated ends of the terraces mark the limit to which the plain was destroyed. When one takes into account their perfect condition he must conclude that either terraces are stable land-forms or that marine erosion on this stretch of coast has been vary rapid and comparatively recent.

There is also evidence of a more recent land-movement still. Along the base of the old marine cliff, referred to previously as bordering the coastal plain, there is a strip of flat land consisting of shingle-beds, sand-dunes, and swamp, half a mile wide and but slightly raised above the sea. It has, without doubt, been formed of detrital matter brought down by the rivers in the vicinity, such as the Ashley and Waipara, as well as by the small streams which flow directly into the sea, their load of waste being distributed by waves, tides, and currents along the base of the old cliff. These accumulations are several miles in length, and their size suggests that there has been either a remarkable increase in the supply of detritus or that there has been a small recent upward movement of the coast. There is no apparent reason why the streams should have been suddenly furnished with an increased load of detritus, although

it must be noted that they are fully charged at the present time, and it is quite conceivable that they could build up a shallow sea-bottom till it was above sea-level without any change in the level of the land. I cannot, however, think that this explanation is altogether satisfactory, and conclude that a small and probably continuous uplift has taken place after a comparatively long period of stability, during which the old coastal plain was eaten back to the line of the former sea-cliff.

Judging from the profiles of the streams joining the Waipara from the flanks of the Deans Range and elsewhere, this movement has extended its effects some distance inland. The loops of the river in the gorge itself, placed as they are in a somewhat narrow trench, may owe their origin primarily to the fact that at a former period the river reached base-level, and that the gorge was cut down to its present depth during a subsequent period of elevation when the river had increased power to corrade, and that now it has again almost adjusted its grade to the load it carries, and all its erosive energy is devoted to destroying the loops that it previously formed. It is very difficult, however, to correlate these effects with certainty.

Origin of the Waipara Gorge.

The circumstances resulting in the formation of the Waipara Gorge furnish one of those interesting problems with respect to drainage directions for which the North Canterbury district is noted. When the river leaves the hills between Mount Brown and the Deans, and issues from the middle gorge, whose existence has been largely determined by the great Mid-Waipara fault, it pursues a course of about seven miles across the Waipara Plains, and, instead of taking the easy path to the sea past Amberley, it cuts a somewhat deep channel through the downs which stretch south-west from the termination of the Limestone Range. Here it runs practically along the strike of the beds which form this somewhat elevated ground. At times it breaks across the strike for a short distance; still, the coincidence is very marked, even when the strike swings round through a right angle. When the river leaves the downs and debouches on to the coastal plain it pursues a direct course to the sea, still following the strike approximately. There seems to be no reason from the present configuration of the ground why this difficult path should have been selected when an easy one was ready to hand, so that it is apparently one of the instances of the anomalous behaviour of rivers which the district furnishes.

The Waiau and Hurunui, a few miles further north, and even the Waipara itself in its upper portion, have cut gorges through mountains composed of hard greywackes and slaty shales of Mesozoic age when they might easily have avoided the obstructions. The only satisfactory explanation is based on the fact that they are instances of "superimposed" drainage. In late Cretaceous and early Tertiary times an archipelago of small islands formed of rocks of Lower Mesozoic age occupied the area now known as North Canterbury and the Amuri districts. In the straits and bays among these islands, greensands, solid limestones, marls, and loose incoherent calcareous sands and gravels were laid down, so that the original surface was completely masked. When the land was raised above the sea in late Tertiary times the course of the streams established upon it was largely determined by the form of the land as it emerged. While cutting down their channels the streams removed a large part of the veneer of loose and readily eroded material, encountered the hard underlying rocks, cut into them, and maintained their original direc-

tions. As time went on more and more of the loose sediments was removed, and the original form of the land-surface completely altered.

The existing Tertiary deposits are in all probability but a small part of those originally laid down, for isolated fragments of these rocks are found in various places high above the present valley-floors, and in such positions that they may well have formed part of an extensive sheet. I think that this is the best explanation of the evolution of the land in the district, as well as of the anomalous courses of the rivers. A similar explanation was also indicated by Captain Hutton in a short paragraph contained in his paper on "The Formation of the Canterbury Plains" (Trans. N.Z. Inst., vol. 37, 1905, p. 467).

It is quite possible, however, that the presence of the Lower Waipara Gorge in the peculiar situation in which it now occurs may be due to a small coastal stream cutting back its head through the escarpments of harder rocks, capturing the headwaters of other small streams, and finally tapping the Waipara itself; but the explanation based on the fact that it is a case of "superimposed" drainage fits the case best.

Stratigraphy.

The question of the stratigraphy can naturally be elucidated by a comparison with other known localities. Fortunately, the Mid-Waipara and the Weka Pass (in close proximity) have become classic in the history of New Zealand geology, having been reported on by nearly all those who have done field-work in this country. In these typical localities the following is a representative sequence, starting from the top, of the beds that have been recorded:—

8. Motunau or Greta Beds.—Sands and conglomerates, mostly calcareous, with shells of *Mollusca* in varying states of preservation, but usually fragmentary. The beds are generally loose and incoherent, but at time concretionary.
7. Mount Brown Beds.—Rough calcareous sandstones with harder concretionary bands, markedly fossiliferous in places.
6. Grey Marl.—Grey and greenish sandstones and blue sandy and calcareous clays.
5. Weka Pass Stone.—Glauconitic and slightly arenaceous limestone.
4. Amuri Limestone.—Foraminiferal and argillaceous limestone.
3. Greensands.—Markedly glauconitic in the upper portions, and with concretions full of saurian remains in the lower part. These beds are often argillaceous, ferruginous, and calcareous, and at times exhibit marked efflorescence of sulphur.
2. Oyster-beds, containing shells of *Ostrea*, *Conchothyra parasitica*, fragments of *Belemnites*, *Inoceramus*, and other shells.
1. Sands and clays with brown coal and impure limonite.

The lower portion of this series is more completely developed further to the north-east, in the Omihi Creek and at Amuri Bluff. According to Hector, Haast, Hutton, Park, and perhaps McKay, the sequence is broken by unconformities, placed in different positions by the different authors, but it is very probable that it is quite conformable throughout. However, it is only the upper part of the sequence with which this paper is specially concerned—that is, with the Motunau and Mount Brown beds, and the Grey Marls and Weka Pass beds, which underlie them. The whole of the banks and terraces bordering the Waipara River as it passes through the lower gorge consist of the sands and conglomerates forming

the highest members of the sequence recorded above; the other beds are, however, in close proximity to the river on its eastern side. The former will be referred to hereafter as the Parcora series, seeing that their fossil fauna shows a close relationship to that of the typical Pareora locality.

Structure and Arrangement of the Beds in the Gorge.

(See map and section).

At the junction of the Omihi Creek with the Waipara River the beds consist of sands, sandy clays with concretionary bands, and conglomerates with shells. The strike is N. 5° W., with a westerly dip of about 22½°. A good exposure is to be seen where a recent flood has removed the surface covering of shingle, and laid bare the solid bank just opposite the mouth of the Omihi Creek. In the Omihi itself, just above the junction, the beds strike north-east and dip to the north-west at 45°. It is evident that the strike here swings round somewhat, a feature which will be readily understood when the general structural features of the locality are considered later, this small movement being only a part of one of wide extent.

On following the river down from the junction, the high banks on the east are found to be obscured by soil and slip-material, but after going about 300 yards the dip observed at the junction changes to the south-east, with the same strike as before. The structure is thus anticlinal, and the same anticline can be distinctly traced for over a

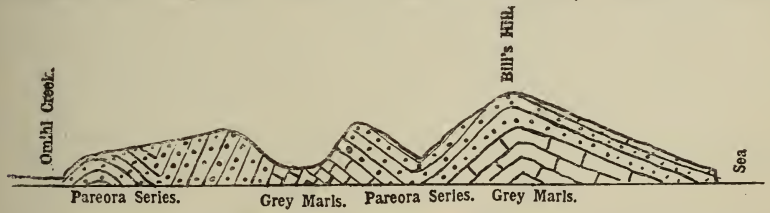


Fig. 2.—Section from Omihi Creek through Bill's Hill to Sea (Five Miles).

mile to the north-east along the bank of Limestone Creek, a tributary of the Omihi coming from the northern slopes of Mount Cass, the stream having eroded a deep channel for some distance along the axis of the anticline. On going still further in that direction the underlying limestones are exposed, with what has all the appearance of an anticlinal arrangement.

Following the banks of the Waipara further down, the south-easterly dip is maintained till the second gully below the Omihi is reached. At the head of this a well-marked syncline is exposed, the western side being chiefly composed of thick beds of fine gravel, but overlying them is a bed of coarse gravel with numerous molluscan remains. These include *Fulguraria arabica*, *Ostrea nelsoniana*, *O. ingens*, *O. angasi*, *Siphonalia dilatata*, *Paphia curta*, *Crepidula gregaria*, *Mactra elongata*, *Ancilla hebera*, *Ancilla australis*, and *Chione intermedia*. The syncline here exposed can be traced to the north-east, parallel to the anticline running up Limestone Creek.

On going still further down-stream the beds dip to the west, and an angle of about 60° is maintained for a distance down the river of about two miles, the strike being between N. 25° E. and N. 35° E. The beds are well exposed in the bluff just below the point where the road from Glasnevin Railway-station meets the river. They consist of sands.

calcareous sands with concretionary bands, and gravel-beds more or less cemented, and are highly fossiliferous. The chief genera to be collected are *Mactra*, *Chione*, *Ostrea*, *Pecten*, *Crepidula*, and also *Bryozoa*. Some beds are almost wholly formed of the remains of *Crepidula*, but they are usually in a poor state of preservation. A characteristic feature of the beds at this point are the massive bands of coarse cemented gravels, dipping to the west at an angle of 60°. For a long distance one of these beds forms one bank of the river, and it can be traced some distance to the north-east on the north side of Mount Cass. Here it dips at a steeper angle, and on going further it is apparently lost under the covering of soil. In all possibility it will reappear in the creeks which flow from the northern side of the Limestone Range.

The same direction of dip and strike is approximately maintained on following down the river to the immediate neighbourhood of a pronounced meander of the stream. The strike here begins to swing round in a positive direction, so that, while just above the loop it is N. 5° E., at the loop itself it is N. 5° W., with a westerly dip, several hard bands of cemented gravel occurring at this point rendering an accurate determination easy. Just past the loop, on the eastern side of the river, and also on the flank of the high escarpment a little further down-stream, the beds consist of sand and concretionary bands full of shell-remains in excellent state of preservation. This is one of the best localities that I know of for the collection of Tertiary fossils, and when thoroughly exhausted will be found to yield a very rich harvest. A list of species collected by Dr. Marshall and myself is given later in this article, and it will be found to show a marked agreement with those collected at the typical Pareora locality, in South Canterbury.

The structure of the beds becomes at this point somewhat complicated, and its unravelment is an interesting problem. On following down the western side of the river below the loop the strike is observed to swing round in the same direction as higher up the river. Just at the mouth of the gorge proper the strike is N. 15° W., with a westerly dip, and just below the Teviotdale Bridge, half a mile further on, it becomes N. 55° W.

In passing through the gorge the strike has thus swung round through a right angle, and its effect is to be seen in the shape of the ridges of the downs towards Amberley, which are found to circle round with it, the outward slope of the downs being generally towards the dip of the beds. At a point about 600 yards above the bridge, at the mouth of a small gully, there has been a marked dislocation of the beds. They have been apparently folded down in an acute isocline, so that the two limbs are approximately parallel; but the beds immediately on either side of it do not appear to be affected, and they do not change their proper level or alter their dip or strike. The disturbance appears to be quite local, and it is not strongly in evidence on the opposite bank of the river. This is the only marked dislocation to be observed throughout the whole length of the gorge, and I have not been able to find any sign of the fault mentioned by Hector (*loc. cit.*).

If we now consider the arrangement of the beds on the eastern side of the river, the structure on the western side can be readily understood. Below the loop mentioned previously, on the slope of the high escarpment which fronts the river to the west and north-west of the Teviotdale Station, the beds dip to the south-east, but an open anticline is clearly visible at the point which projects into the river half a mile below. The axis of this anticline is not horizontal, but pitches to

the south-west, and thus the gradual swing-round of the strike of the beds to the west of the river is easily explained. The amount of pitch must be considerable, for the lowest beds actually exposed in the gorge, at a height of about 100 ft. above sea-level, are the Grey Marls, whereas the limestones which underlie the marls are exposed on Mount Cass, about three miles to the north-east, at an elevation of 1,700 ft. It is possible, also, that the anticline not only pitches, but dies out as well. It is certain, however, that it is distinctly unsymmetrical, and the western limb dips down at a steeper angle than the eastern limb.

The direction of the strike observed in the river near the axis of the anticline changes on following the escarpment towards Mount Cass. It is at first parallel with the river, but, on being followed further, strikes north-east with a dip to the south-east, and the beds forming it lie in just the same relation to the limestones of Mount Cass and the Limestone Range as the Mount Brown beds in the Weka Pass do to the limestones occurring there. The similarity of the arrangement is most marked. If the creeks between the escarpment and Mount Cass be examined, the "Grey Marl" of the Survey is found in its proper position and with characteristic development; but only the upper sandy beds of these marls are visible in the gorge itself in the immediate vicinity of the loop of the river and in the reach below it. The axis of the anticline which runs out in the Waipara continues to the north-east, the limestone of the Mount Cass ridge forming the limb dipping to the south-east, while the north-east limb is represented by isolated blocks to the north of the Limestone Range. At the core of the anticline, immediately to the north of Mount Cass, lies a prominent hill, formed of the underlying greywackes of Mesozoic age. This arrangement is exactly what might have been expected from a consideration of the structure and relationship of the beds in the Weka Pass and the Mid-Waipara

As the anticline is traced to the north-east from the river it appears to change to one of increasing asymmetry, so that some of the hard concretionary bands on reaching to the inland side of Mount Cass become nearly vertical. It is possible that on being followed further north-east still it grades into a fault with a downthrow to the north-west, since the limestones near the southern edge of the Omihi Valley, in the neighbourhood of Limestone Creek, show a marked discordance in level between those forming the crest of the ridge of Mount Cass, although they dip in the same direction. More accurate examination of this part of the country is necessary before a satisfactory conclusion can be arrived at.

The apparent bend in the axis of the anticline near the Waipara River is perhaps due to this asymmetrical character, associated with the pitch of the axis; it may, however, be due to a disturbance caused by folding of the beds to the east of the mouth of the river in the neighbourhood of the Teviotdale Station.

On all the stretch of country forming the triangular area between the Waipara River and the Teviotdale Creek the strike of the beds is uniformly N. 55° W., with a southerly dip. They consist of sands, sandy marls, loose gravels, and hard bands of conglomerate, composed of large pebbles of greywacke and full of fossil-fragments. The beds are so hard, however, that they rarely yield good specimens. One of the hard bands forms the escarpment to the south-west of the Teviotdale Station; another forms a low indistinct parallel ridge to the north of this; but the most

prominent is a massive and solid bed on the north of the station, which runs out to the coast at a prominent rocky point to the east of the river-mouth. The immediate coast-line at this point consists of large blocks derived from this bed, and its continuation seaward is marked by a line of submerged reef. Fossil remains are very common in this bed, specially remains of *Mollusca*, and notably a flat sea-urchin (*Arachnoides placenta*), but the rock is so firmly cemented that it is almost impossible to obtain good specimens.

This hard bed is primarily responsible for the shape of the ridge known as Bill's Hill, which lies to the north-east of the Teviotdale Station. Its peculiar position presents a somewhat difficult problem till it is recognized that the hill is an anticline, and that it is flanked on the north by a small syncline now coinciding approximately with the upper valley of the Teviotdale Creek. The northern side of this creek is formed of beds dipping to the south-east and rising to the north-west till they form the prominent escarpment facing Mount Cass on its southern side. The Bill's Hill anticline owes its preservation from denuding agents to the protection of its upper surface by the layers of hard conglomerate which covers it almost continuously, although individual layers are somewhat discontinuous in their extension, one band being frequently replaced by a slightly lower and parallel one on frequent occasions. Nevertheless, the total effect is to cover the hill and protect it from active denudation.

The axes of both the anticline and its accompanying syncline run approximately N.E.–S.W., but they peter out between the Teviotdale Station and the river. It is possible, however, that they have exerted some disturbing effect on the main structural anticline, which runs from Mount Cass towards the river; and perhaps the curvature of its axis is due to the coalescence of the two lines of folding as they are followed to the south-west. A very complete examination of the locality is, however, necessary before the precise effect of each fold on its neighbour can be determined.

It will be observed that all the axes of folding enumerated above are approximately parallel, and they are also parallel to the folds which the Cretaceous and Tertiary series at Amuri Bluff and Kaikoura exhibit so markedly. These folding movements have therefore extended well into North Canterbury. Their presence in that locality, and also in the Trelissick basin, described by McKay and confirmed by examination by the present writer, suggest strongly that earth-movements connected with the folding of the great alpine chain had probably not ceased even late in the Tertiary era, although they were certainly more acute in the Kaikoura district than further south, and were, besides, of a different order of intensity and character from those primarily responsible for the formation of the great mountain-range.

The thickness of the beds exposed in the gorge certainly exceeds 1,800 ft., and all through them, as well as in the underlying Grey Marls and limestones, there is no sign of any discordance or dislocation other than folding, with the exception of the local disturbance referred to on page 228. The special importance of the absence of any evidence for a physical break will be understood when the fossil content of the beds has been considered.

In many parts of the area the solid strata are covered with a veneer, of greater or less thickness, of what are evidently river-gravels, in addition to the covering of recent marine shingle on the coastal plain. These may have been derived from rivers which flowed over the country at higher levels than now, of which there is abundant evidence in the downs

to the south-east of Mount Grey, but in many cases the pebbles have been weathered out of the conglomerates which form a fairly large percentage of the beds of Pareora age in the vicinity of the gorge.

List of Fossils collected.

The following is a list of the fossils collected by Dr. Marshall and myself on various visits, the determinations in nearly all cases being made by Mr. Suter :—

Anomia sp.
Cardium patulum Hutt.
—— *spatiosum* Hutt.
—— *greyi* Zitt.
Chione meridionalis Sow.
—— *stuchburyi* Gray.
—— sp. Near *C. chiloensis*, but distinct, and probably new.
—— sp. nov.
—— sp. nov.
Crassatellites amplus Zitt.
*Cucullaea alta** Sow.
Diplodonta zelandica Gray.
Dosinia magna Hutt.
—— *subrosea* Gray.
—— *greyi* Zitt.
—— *lambata* Gld.
Glycimeris globosa Hutt.
—— *laticostatus* Hutt.
Lima paleata Hutt.
—— *bullata* Tate.
Lutraria solida Hutt.
Macrocallista multistriata Sow.
Mactra elongata Quoy & Gaim.
—— *chrydaea* Sut.
Mesodesma grande Hutt.
—— sp.
Mytilus caniculus Mart.
Ostrea nelsoniana Zitt.
—— *ingens* Zitt.
—— *angasi* Sow.
—— *edulis* Linn.
Panopaea orbita Hutt.
—— *zelandica* Quoy & Gaim.
Paphia curta Hutt.
Pecten crawfurdi Hutt.
—— *hillii* Hutt.
—— *williamsoni* Zitt.
—— *(Pseudamussium) huttoni* Park.
Spicula aequilateralis Desh.
Tellina sp. Near *disculus* Desh.
Venericardia australis Lam.
—— sp. Probably new.
Ancilla australis Sow.
Ancilla depressa Sow.
—— *hebera* Hutt.
—— sp. Near *australis*.
—— sp. nov.
Bathytoma sulcata Hutt.
Bela robusta Hutt.
Calyptraea scutum Less.
Cerithidea sp.
Crepidula gregaria Sow.
Cylichnella enysi Hutt.
Epitonium rugulosum lyratum Zitt.
Galeodea senex Hutt.
—— *sulcata* Hutt.
—— sp. Small variety; probably distinct.
Fulguraria arabica Mart.
Polinices callosa Hutt.
—— *huttoni* von Ihering.
—— *ovatus* Hutt.
—— —— New var. *imperforatus* Suter non ed.
—— *hamiltonensis* Tate.
Olivella zealandica Hutt.
Trochus tiaratus Quoy & Gaim.
Struthiolaria cincta Hutt.
—— *cingulata* Hutt.
—— *tuberculata* Hutt.
—— *caniculata* Zitt.
Terebra biplex Hutt.
—— sp. Near *biplex* Hutt.
—— sp. nov.
Trochus tiaratus Quoy & Gaim.
Turbo sp.
Turritella sp.
Volutospina (Athleta) huttoni Sut. (= *V. kirki* Hutt and *Kirki kirki*).
Dentalium solidum Hutt.
Balanus sp.
Arachnoides placenta sp. (?).
Meandropora.
Myliobatis sp. (?). Teeth.
Ribs of cetaceans.

* This species was collected in February at the Lower Waipara by Dr. Allan Thomson and Mr. C. A. Cotton, and a specimen given to the author.

In addition to the above, the following species are recorded by Haast as occurring at the Lower Waipara Gorge ("Geology of Canterbury and Westland," p. 321) :—

Cytheria enysi Hutt.
Venericardia intermedia Hutt.
Modiola albicosta Lam.
Modiola sp.
Lima crassa Hutt.

A careful comparison of this list with the list of present species of *Mollusca* found fossil given by Suter (Trans. N.Z. Inst., vol. 42, 1910, p. 8) shows that more than 30 per cent. of the species given above are now living in New Zealand seas. Although the list of Waipara fossils will no doubt be greatly amplified by more careful search, the relative proportion of species to those existing now is not likely to be much altered. Judging from this percentage, the beds should be classified as Upper Miocene or Lower Pliocene.

A further comparison with the list of fossils found at the typical Pareora locality, in South Canterbury, shows that of sixty-four named species given in the Waipara list thirty-two are to be found in the lists of species collected at Pareora given in Haast's "Geology of Canterbury and Westland," in Park's paper "On the Marine Tertiaries of Otago and Canterbury" (Trans. N.Z. Inst., vol. 37, 1905, p. 530), and among the fossils exhibited in the Canterbury Museum. This is at first sight a somewhat small proportion, but the forms common to both include a very large number of characteristic species, and it is possible that further collection may bring about further accordance. In any case, the number of characteristic genera common to both localities renders it a matter of certainty that the beds in the Lower Waipara are contemporaneous with those in the typical locality at Pareora.

A further comparison with the list of the fossils collected by Park on the Mount Donald escarpment (*loc. cit.*, p. 540), and with the lists of Mount Brown fossils given by Haast ("Geology of Canterbury and Westland," pp. 306–11), and also by Hutton in his paper on the "Railway-cuttings in the Weka Pass" (Trans. N.Z. Inst., vol. 20, 1888, pp. 261–62), shows a certain amount of agreement of the Lower Waipara fossils with those collected in the typical Mount Brown localities. There are, however, some differences, notably the absence of Brachiopods from the Lower Waipara, in marked contrast to their extraordinary numbers at Mount Brown. This may be due either to the fact that the proper horizons for these fossils have not been discovered in the Waipara, or that the conditions for their existence or for their entombment were not favourable in that locality when the beds were laid down. The accordance of the fossil content is, however, sufficiently close to assign both sets of beds to the same age, especially when the associated fossil species from other localities of the same age are taken into consideration. The stratigraphical relations also strongly support this conclusion.

Since by far the greater number of the fossils enumerated in the list can be collected on one horizon in the gorge—*i.e.*, just above the Grey Marls—it is reasonable to consider that the lowest beds intersected by the river are of the same age as the Mount Brown beds, while the upper members are probably of the same age as the Motunau or Greta beds, and the conformity of the sequence in the gorge supports the opinion of Hutton that the Mount Brown beds are the base of the Pareora system, and the absence of any unconformity in the gorge also supports his contention

that there is no stratigraphical break between the base of the Mount Brown beds and the top of the Greta beds.*

The circumstances are also favourable to the position maintained by Marshall, Speight, and Cotton in the paper on the Tertiary series published in last year's "Transactions of the New Zealand Institute"—that there is no stratigraphical break in North Canterbury between beds at the base of the Waipara system characterized by the presence of saurian remains, *Belemnites*, *Conchothyra parasitica*, and various species of *Trigonia*, and beds which have a fauna which must be assigned to the Miocene or even the Lower Pliocene period. This statement does not, however, negative the existence of a palaeontological break.

Conclusion.

For the purpose of aiding people who wish to examine this interesting locality, I make the following suggestions as to the means of visiting it. The lower portion of the gorge is best worked from Amberley, which is distant about three miles, with a good road suitable for driving or bicycle. The upper part can be reached most conveniently from Waipara, whence a walk or ride of about two miles will bring one on to the upper entrance to the gorge. If time is limited, and only one day is available for the visit, the Glasnevin Railway-station affords the shortest and readiest access to the middle part of the gorge. There is a good road leading from this station to within a short distance of the place where abundant fossils are to be found. At either Amberley or Waipara there are hotels at which accommodation can be obtained.

Explanation of Plates.

In considering the map and section accompanying this paper it must be noted that recent alluvial and marine deposits have not been marked. It was found impossible to do this accurately without examining almost every acre of the country; only the underlying solid beds are, therefore, represented.

* In Trans. N.Z. Inst., vol. 37, 1905, p. 538, Park says, "The Motunau beds lie on a denuded surface of the Mount Brown beds, and the section is so clear that no doubt can be entertained as to the unconformable relations of the two formations"; but in a recent paper published in the "Geological Magazine" (5th December, vol. 8, p. 548) he admits the physical conformity of the Mount Brown and Motunau beds. His exact words are, "The unconformity which I thought I recognized at Waipara between the Mount Brown and Motunau beds may not exist, or, if it does, it may be purely local. In my classification of the Jamger formations adopted in my 'Geology of New Zealand' I have recognized only one physical break [in the Tertiary succession]—namely, one between the Oamaru and Waipara series. Nothing I have seen since the publication of that work has led me to alter the opinion I then expressed." The author is therefore glad to know that his position as to the conformity of the Motunau and Mount Brown beds is quite in agreement with the most recently expressed opinion of Professor Park on a somewhat important point in our Tertiary stratigraphy.

Art. XXV.—*Notes on Nest, Life-history, and Habits of* Migas distinctus, *a New Zealand Trapdoor Spider.*

By J. B. Gatenby.

[*Read before the Wellington Philosophical Society, 7th June, 1911.*]

Plate XV.

I have to thank Mr. P. Goyen for identifying this species, and also Professor Kirk for his many kindnesses to me.

Migas distinctus is a small black spider belonging to a genus which includes two other species—*M. paradoxus* and *M. sandageri*.

The Nest: its Parts. (Fig. 14—a clay bank.)

Lid, or Trapdoor. (Fig. 9, *a*, *b*, *c*.)

Measurements.—Taken lengthwise (for the lids of the adult specimens are seldom exactly circular) (fig. 7, *e*), the lid measures $\frac{2}{5}$ in. to $\frac{3}{5}$ in.; taken across, it measures $\frac{3}{10}$ in. to $\frac{2}{5}$ in. The lids always vary in thickness. If a nest is located in a mossy bank, the lid is thick, so that the surrounding growths will spread to the surface of the door. If the lid is situated in a hard, bare, clay bank, the spider, not needing to provide rooting-surface, covers the door with a thin cement layer. A thick door is often $\frac{1}{6}$ in. through; a thin door often less than $\frac{1}{24}$ in.

Construction of Lid.—The adult's lid is a compound structure, consisting of several layers. The number of layers is never less than two, and seldom more than twelve. Where the bank is mossy, the layers are generally two—viz., a thin silk layer and a thick earth layer. If the locality is dry and poor in growths, the lid has one very thin cement-clay layer on top, and from four to twelve separate silken layers (fig. 7, *a*, *b*, *c*, *d*, *e*—stages in growth).

Layers of Lid.—Many adult lids show a rough, layered upper surface (fig. 7, *e*) caused by the enlargements of the door. Each silken layer is thicker at the edges than in the centre, and appears in texture like a piece of linen. The material for the top, or the earthy layer, is scraped from near the nest, and fine stones and pieces of vegetation are frequently mixed together with the earth; hence the door becomes very inconspicuous. Where the bank is lumpy, doors are sometimes constructed from small, entire, irregular pieces of earth, cut flat on one side, and hinged.

Situation of Hinge.—The tube of the nest is very seldom straight, but enters the ground with a curve (figs. 9, 10, 13, &c.). The hinge is invariably situated towards the curved terminus of the tube. Fig. 13 shows the natural position of tube, the hinge being on top, and hence the door always shuts with its own weight. The hinge is often with only one layer, but the remaining layers (sometimes five in number) are continued above the hinge itself with a little upward twist (fig. 9, *a*, just above arrow). This silken projection only allows the door to rise to an angle of 60°. Often the side near the hinge is sunken into the ground, and a ridge hangs over the depression (fig. 9, *b* and *c*, near the arrow);

hence when the door rises the projection catches the back of it and keeps it at an angle of 60°. On most doors these devices are present to a certain degree, but some doors are without them. It is difficult to say whether or not these above-mentioned devices are made on purpose by the spider.

The Manner in which the Spider makes her Lid.—The spider begins by weaving a tag-like piece of silk on the hinge side. Having collected fine pieces of earth and stones near by, she gums them one by one to the tag. After she has got a little patch gummed together she turns around in her nest, applies her spinners to the little mosaic, and spins a silken layer under it, which binds it temporarily. She then goes on gumming the pieces together till the door-opening is covered. She then again turns around, and spins another covering over it. In this state the door is flimsy and elastic, and when the spider pulls at it from within (fig. 11) it drops into the mouth of the tube. Some spiders perform their building in a night, others in some days. They generally work at night, although sometimes in daylight. The gum appears to be exuded from the mouth.

The Tubular Cavity of the Nest.

The depth and width of the tube varies greatly, depending, of course, upon the size of spider. Generally the nests are from 1 in. to $1\frac{1}{2}$ in. in length, and $\frac{3}{10}$ in. to $\frac{2}{5}$ in. in width, taken lengthwise at the lid. The tube does not remain a uniform width in its entire length, but widens at the terminus to $\frac{1}{2}$ in. (figs. 9, 10, 11, 12, &c.). The reasons for this terminal swelling are two—firstly, to allow room for eggs and young; and, secondly, to allow the spider to move and turn around in the nest.

Lining of Tube.

The interior of the tube is lined with a layer of silk, which is thick if the ground is dry or crumbling, thin if it is damp and firm. The rim of the mouth of the nest is generally thicker than the other linings.

Abnormal Forms of Nests.

If a bank is very hard or stony the spider is unable to pierce the ground deep enough. In this case many kinds of curious nests are seen. The spider generally scrapes out a shallow groove, and makes her silken tube in it. Hence a good deal of the nest is exposed, and to cover it the spider uses an earthy cement-like mixture of mud and stones (fig. 10, *c*). This is spread over the silk until the projecting unprotected side of the tube closely resembles a rounded stone or piece of earth. The work is marvellously executed, and until the door is discovered it is impossible to detect the artificial side of the tube. The door is discovered on account of the round rim. Sometimes the groove cannot be scraped deep enough, and then the spider makes a small nest like a nut, the door being on one side. This protrudes from the bank, and is covered so as to resemble a stone.

Another curious form of nest is that with two doors, one at each end of the tube (fig. 13). These two-doored nests are met with in tubes built under stones, on cliffs, and sometimes on trees. Sometimes both doors are large enough for the spider to pass through, but more frequently only one door is the proper size, the other one being too small. I believe that when the young spider builds the nest both doors are large

enough for her to pass through, but that after a while she neglects to enlage one of them, and only attends to the other. I have seen small tubes with two very fine doors; large tubes with two proper doors are rare. Why the spider should build a door at each end of her nest is hard to say. I believe that she must lose sight of the fact that she has already made one door, and, as there is no ending or terminus to the nest built under a stone, &c., as in a normal nest built in an earth bank, she naturally makes a door at each end of the tube. Afterwards she uses only one door and neglects the other. This suggestion credits the spider with little intelligence.

How Rain and Wind affect the Nest.

In exposed situations banks are gradually worn away by the elements; consequently nests are frequently seen blown half out of the bank (fig. 14, lowest). The spider has no remedy for this, except to spread cementitious mud-mixture over that part of her home which is laid bare. Fig. 14, lowest, shows a nest in the process of being denuded. Nests in this state are very conspicuous, and I have known a spider to extend her tube farther into the bank, so as to make it twice as long as before, the old door, &c., still being used (fig. 14, middle). Water seldom enters the tubular part of the nest, although the silk often becomes thoroughly saturated.

About the Male and his Nest. (Fig. 2.)

As the male is much smaller than his mate, he uses a smaller nest. I say "uses," because I believe that he seldom builds a nest of his own, and then only under certain circumstances. Firstly, I should say that the female does not eat her mate after he has accomplished his purpose. Repeatedly I have kept males and females through the breeding season, and in every case the female refrained from dining on her lord. I have found males living in the same bank with females, and, although food was scarce, the male was untouched. Hence I know that this cannibalistic male-eating habit is not in vogue among *M. distinctus*.

It is only when the male is living in a small colony or away from the females that he is found in a nest which is in good repair, well hidden, and not too big or too small for him. Males living among big colonies are more often than not found in nests which are in disrepair. Especially in the breeding season are they so found, for after this is over the males retire into discarded nests, which they soon bring up to a good state of repair. The nests they adopt are those which have lost their occupants by some accident.

The male is never found in the female's nest with the female, but the courting is done around the mouth of the tube. Evidently the male does not like the idea of trusting his life to his mate; and he could be ill spared, for, as males of this species appear to be scare, the propagation of young would be slight if every female managed to slay her mate.

In the breeding season the male wanders over the bank at night, and when day breaks he hies himself to an old nest, chink, or cranny, and there awaits night. It is necessary for him to wander about, because the females' nests are so scattered. Although the fewness of male spiders as compared with female ones is sometimes exaggerated, I feel correct in saying that the males are generally in the proportion of about one to thirty females.

Life-history.

About the months of February and March the female lays from thirty to sixty small white eggs. These are placed between the wall of the nest and a piece of silk stretched across a rounded part of the tube (fig. 10, O, the arrow).

The egg-bag is placed variously in the nest, but in fig. 14 (top) the commonest position is shown. The piece which stretches across the sides of the tube is $\frac{2}{5}$ in. in diameter. Separate egg-cases, with two sides, not connected to the tube, are rare. The young emerge and lie dormant inside the case. After a week or so the mother removes the covering, and often weaves in lieu of it a transparent filament-like veil of silk over them (fig. 10, *b*).

After the young become strong enough they push out of the covering, and wander out of their old home. Often some few remain with their mother, and frequently are met with as late as the end of April. These must be provided with food by their parent, for they are often a fair size.

When the young emerge from the parent nest the majority are pounced upon and eaten by an eager, hungry horde of bank-inhabiting, vagabond spiders. Few escape; those that do proceed to burrow their tiny tunnels and to make their nests. They bite out the earth with their falces, which are very strong. Of course, the state of the earth determines the length of time taken to make the boring. The doors of the nests of young spiders are round, very small, being less than $\frac{1}{12}$ in. in diameter, and very difficult to detect. As the spider grows she needs to enlarge her door.

Enlargement of Tube and Door.

If the food-supply is good the spider grows rapidly, and soon the nest becomes too small for her. When she wishes to enlarge her nest she tears away one side of the silken lining of the nest and widens that side in its entire length. She then spins a silk web over this. The door is enlarged as shown in fig 7, *a*, *b*, *c*, *d*, *e*. Fig. 7, *a*, shows a door which has been enlarged once, the original door of the young spider being the circle inside the larger door. Fig. 7, *e*, shows a door which has been enlarged six times. Nests are seen with nine or ten enlargements.

When the spider wishes to enlarge her door, after having enlarged the tube, she spins under the old door an entire silk layer the size of the newly enlarged tube. The door after a few enlargements becomes very ragged, and hence less conspicuous. The newly spun layer is covered with earth where the edge protrudes beyond the rim of the old door. Where the lids have a thick earthy layer, and only one or two silken ones, the spider cements a rim of earth around the old door and then spins a web underneath it. I believe the spider enlarges her door and tube six or seven times during her life.

The Spider's Enemies, etc.

Although encased in a strong tube with a deceptive door, this Arachnid is not free from enemies. The greatest destroyer is excessive heat. In the middle of summer the banks, especially the clay ones, become very hot. Unless the spider is able to capture enough juicy insects to assuage her thirst she soon becomes dusty and emaciated, and ultimately succumbs. Sometimes before she dies, in a last despairing effort to evade the ardent rays of the sun, she weaves a silken partition between herself

and the door (fig. 10, *c*, the arrow). In many cases she is found dead behind this screen, while her door, after warping with the weather, allows the entrance of all sorts of vermin—woodlice, centipedes, aptera, small spiders, and a large number of other forms of insect-life. These cannot reach her, for the screen shuts them off.

Unless there is an absence of moisture, hunger has no terrors for these spiders, for they are easily able to exist without food for three or four months. Frequently in a famine a spider devours her neighbour, a hard fight always ensuing first.

I have several reasons to suspect that *Pompilius fugax*, &c., is a keen enemy of *M. distinctus*. I have caught *P. fugax* dragging a trapdoor spider across a bank. Whether the spider was caught by the fly by the latter opening the door, or by the spider jumping out to catch the fly and instead catching a Tartar, I know not, but I have more than once found a pupa-case of a small Ichneumon fly lying among the remains of a spider.

The Spider's Age.

This is a question I could not definitely settle, although I have kept specimens three years and a half. Unfortunately, I was obliged to travel to the north for a holiday, and my pets were put with their box in the garden, and when I returned the only remaining member of the thirty spiders was a young one three months old.

I know that some spiders take two to three years to reach maturity, but if the food-supply is short the time may be longer. I have kept mature spiders three years and a half, and possibly they would have lived much longer. Hence the spider may be six or even seven years old when it dies.

The Food of *M. distinctus*.

This consists mainly of *Diptera* and small *Lepidoptera*. The young eat small organisms like *Aptera* (*Podura*). While catching her food she shows a cleverness that is immensely superior to that of other sedentary spiders.

On fine sunny days flies and other insects hover about the banks. Now and again they will alight on the bank near a group of nests. The spiders, if they are hungry, keep on the alert; when one hears a fly she creeps up from the bottom of her den, lifts the door slightly, and reconnoitres (fig. 10, *b*). Whilst peering out the spiders often become rather excited when an unsuspecting fly draws nigh, and this is shown by the rash way in which they sometimes open the door; the fly then discovers its enemy, and escapes. This makes the spider more circumspect, and the next fly that draws nigh is watched more carefully.

The person who is watching the hunting operations of the spider is compelled to admire her great patience, and also the way she controls, with a front leg, the peeping-out space between the door and the rim of the tube (fig. 10, *b;* notice the bent leg). At last her patience is rewarded: a fly accidentally alights right in front of the treacherous door; the spider throws open the trapdoor and leaps right upon the back of the fly, driving her falces into it (fig. 8). She withdraws quickly into the tube, and pulls the door till it shuts firmly. Then she crawls down to the end of her tube and devours the fly. The capturing takes a very short time, and unless the observer watches closely he will miss the whole operation.

She will seldom dash out unless the fly is right in front of the door. If it is too far away she would be obliged to expose her body to danger while she reopened the door. As it is, her abdomen keeps the door open, so she soon slips back. When the spider has eaten the fly she drops out of the door those parts which she discards.

I kept thirty spiders in a small box placed on a shelf. On the sunny days when the flies were about I would sprinkle a few grains of sugar in front of each door, and put the box in the sun. The unsuspecting flies would come to feed on the sugar, and would fall easy prey to the spiders. In winter, when few flies were about, on the fine days I would catch house-flies and tie cotton to their wings, and make them walk over the door. The spiders would drag them in, cotton and all. Next day the cotton, with the dry carcase of the fly, would be found often an inch from the door.

Spiders may be killed whilst attacking an Ichneumon fly inadvertently. This would explain why nests, even in a plentiful insect season, are found tenantless, except for vermin.

Even when not looking for food, spiders will be caught watching out of their nests. Before they emerge at night they always reconnoitre for an hour or so. If a spider is alarmed she rushes up from the terminus of her tube and proceeds to resist an entrance.

THE SPIDER'S *modus operandi* WHILST HOLDING DOWN HER DOOR.

Four legs (the front pairs) are, together with the falces, used to fix on the silken underlining of the door. The falces are driven into the middle of the door, the four legs being placed so that the claws hold to the edges of the lid (fig. 12). The thick bristles on the ultimate and penultimate joints of the first two pairs of legs present a spiny array (fig. 1, female; fig. 2, male). (Fig. 3 shows a few of these terminal protective bristles, with the claws.) The remaining pairs of legs are placed around the tube, the claws sticking into the silk lining (fig. 11). All the legs are slightly bent when holding on, so that the spider's hold is elastic, and better able to withstand a jerk. When in this position the spider pulls the door tightly, often exerting a force capable of lifting a half-ounce weight.

Fig. 11 shows the profile of a spider holding her door. It will be noticed how well the spider's abdomen is protected by the curve in the side of the tube.

Sometimes whilst frantically resisting the entrance of an enemy the spider will suddenly let go the door and make as if to rush out on the intruder. If a person has his hand near when this happens he quickly drops the pin with which he has been holding the door, and removes his hand to safety. But this is apparently what the spider wishes to happen, and immediately she turns on her back again (fig. 11) and closes the door. The whole business is a ruse on the part of the spider, for she would not forsake her nest to bite any enemy.

Some spiders relinquish their hold when they perceive that they are weaker than their enemy, but they remain watching nearly hidden around the bend of the nest. Some spiders run to the bottom of their den when beaten at the door, and seek to hide themselves.

In wet weather spiders often remain at the end of their dens even when the door is touched. In captivity spiders often weave some strands

of silk between the door and rim, in order to keep out an intruder (fig. 10, *a*, near letter D). Sometimes they do this whilst hibernating. If the tube pierces the bank in a downward direction, in order to protect its abdomen while still holding the lid it would be obliged to hinge the door on the bottom side of the open. Consequently the lid would be continually falling open with its own weight. Hence the tube pierces the bank in an upward direction (fig. 14).

Habitat.

This spider is seldom found many miles from the sea-coast. The spiders prefer a sheltered bank, never, as far as I know, burrowing into the ground, as some other trapdoor species.

Spiders of the same species from different localities often show curious differences in habits and manner of building their nests. This is taken into account when I say that the results may be slightly dissimilar if spiders from provinces other than Auckland or Wellington are studied.

I have been disappointed to find that *M. distinctus* is free from parasitic *Acarina*.

EXPLANATION OF PLATE XV.

Fig. 1. *M. distinctus*, female; × 2.
Fig. 2. „ male; × 2.
Fig. 3. Tarsus of female, front leg, showing bristles.
Fig. 4. Terminus, female palpus.
Fig. 5. Male palpus, side view.
Fig. 6. Eyes.
Fig. 7. *a*, young spider's door, and so on to *e*, the adult door, from above.
Fig. 8. Female leaping on back of fly (see fig. 10).
Fig. 9. Side view of sections of nests, showing different devices for keeping the door from opening too far.
Fig. 10. Female watching a fly, which is unaware of its danger. (Fig. 8 shows what happened a second later.)
Fig. 10. *a*, at D, strands of silk woven to keep the door closed; O shows position of egg-bag (see fig. 14, top). *b*, at arrow, film of silk woven over young spiders. *c*, M shows partition often woven by moribund spi 'er.
Fig. 11. Female holding door against intruder (profile).
Fig. 12. Same from above, showing position of legs, &c.
Fig. 13. Nests built under a stone. Both have two doors, one at each end.
Fig. 14. Top nest with egg-case; middle nest which has been denudated, after which the spider has bored in farther; lowest a nest built near surface on account of hardness of earth. (Fig. 14 also shows a bank in which the nests are in their natural position.)

Fig. 8, 9, 10, 11, and 12 do not, of course, show true position of tube; they should be as in fig. 14; but if drawings are turned around, the proper effect is obtained.

Migas distinctus.

Face p. 240.]

Art. XXVI.—*Some Features of the Circulatory System of* Heptatrema cirrata *Forster*.

By Professor H. B. Kirk, M.A., Victoria College, Wellington.

[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

Plates XVI, XVII.

During this year I obtained several specimens of *Heptatrema cirrata* Forster. In this paper I give a short account of the circulatory system, which presents some features of interest. As there are not in New Zealand the publications containing the papers of most of the workers on Myxinoid anatomy, I do not go into any great detail in this paper.

Ten specimens were at different times injected. Injections were made into the ventral aorta, the dorsal aorta, and usually one of the posterior cardinal sinuses. Although the injection of *Heptatrema* is often very effective, it is apt to be capricious. Usually an injection thrown into one of the posterior cardinal sinuses suffices to fill the whole venous system, but at times such an injection fails in one part or more. I have not yet attempted to inject the lymphatic system, which, from the extent of the subdermal lymph-spaces, is probably extensive and diffuse. I have found gelatine the most suitable injecting vehicle.

The circulatory system of *Heptatrema* presents, as might be expected, many resemblances to that of *Bdellostoma*, but it presents also some notable differences. The ventral aorta, for example, branches before any afferent branchial arteries are given off; the jugular system achieves great development; the short subintestinal vein passes direct to the right hepatic portal vein, not to the sinus venosus.

Heart.—The sinus venosus is, as usual, thin-walled, and it presents no considerable dilatation when fully injected. The atrium has thick, spongy, and muscular walls. It dilates greatly when injected, and then often presents a lobulated appearance. The passage from the atrium to the ventricle is guarded by a single pair of deep "pocket" valves. The wall of the ventricle is enormously thick, and its cavity is small. The passage to the short bulbus aortae is guarded by a single "sleeve" valve of peculiar construction. The base of this "sleeve" is attached to the wall of the ventricle, and the "sleeve" projects into the bulbus. It is not, however, free, but each side has a line of attachment to the wall of the bulbus. These lines of attachment are dorso-lateral and ventro-lateral. The terminal portion of the "sleeve" is wider than the basal portion, and the edges of this terminal portion tend to fall together, closing the passage.

Ventral Aorta.—Except for the short bulbus, there is no median portion of the ventral aorta, forking of the aorta taking place immediately. Each division of the aorta runs for about 1 cm. before it gives off the earliest of its afferent branchial arteries. The afferent branchial arteries are long and curved, an arrangement that fully provides for the great dilatation of the pharynx that takes place when large pieces of food are passed along it. Each afferent branchial artery enters the wall of the gill-sac on its posterior aspect just below the point of origin of the excurrent branchial tube. The most anterior of the series of gill-sacs is supplied by the terminal portion of the division of the aorta.

With regard to the forking of the ventral aorta, it is perhaps worthy of note that in two preparations that carry much injection the right division of the aorta appears as though it sprang from the left.

Dorsal Aorta.—As in *Bdellostoma*, the efferent branchial arteries do not run direct to the dorsal aorta, but those of each side run to a vessel that may, for the sake of convenience, be called a lateral aorta. This occupies a dorso-lateral position parallel to the dorsal aorta, to which it sends regular communicating vessels. These communicating vessels are three in number on each side. The most anterior of these vessels are behind the second pair of gill-sacs. In "A Treatise on Zoology" (Ray Lankester) Goodrich represents in diagram the circulatory system of *Bdellostoma*, the diagram being based on the figures of Müller, Jackson, and Klinckowström, to which figures I have no access. The diagram shows that the lateral aortae of *Bdellostoma* have more connecting branches to the dorsal aorta than those of *Heptatrema*, and that in *Bdellostoma* there is communication anteriorly to the first gill-sacs. In front of the gill-sacs the lateral aortae of *Heptatrema* can be traced forward nearly to the head. Posteriorly they turn inwards about abreast of the last gill-sacs to join the dorsal aorta, which has, of course, received all its blood through them. The turn inwards is made at a noticeable angle, and the last efferent branchial vessel of either side may not be received until after the turn is made (see Plate XVII, fig. 1).

The efferent branchial arteries leave the gill-sacs on the anterior aspect. Those of the anterior pair always, and those of the second pair nearly always, branch just as they leave the gill-sac, the two branches entering the lateral aorta separately. The third, and sometimes even the fourth, efferent artery of one side, or both, may branch in like fashion. In the preparation figured in Plate XVII, fig. 1, the second efferent branchial artery of the left side has a distinctly double origin.

From the median dorsal aorta vessels are given off to supply the notochordal sheath, the pharynx, and the body-wall. These last, the segmental arteries, often alternate with each other, but posteriorly to the heart a more or less regular arrangement in pairs becomes evident. One segmental artery often suffices for two myomeres.

I have not been able to observe the blood-supply of the pro-nephros. With regard to the nephridial system, each segmental artery that crosses the system sends, typically, a branch to the corresponding glomerulus. In cases—and they are frequent—in which there is no segmental artery corresponding to a glomerulus, a renal artery runs direct from the aorta (see Plate XVI, fig. 2). One case was observed in which a segmental artery sends branches to two glomeruli.

Posteriorly to the heart splanchnic arteries run from the dorsal aorta to the intestine; the splanchnic arteries are numerous, and appear to be one in each segment.

Numerous slender arteries pass from the dorsal aorta to the gonads. These arteries are much more noticeable in cases in which there are many ova forming.

Jugular System.—There is a large right jugular vein lying above the lingual mass and beside the pharynx. It arises well forward, abreast of the fifth slime-gland. The vessels that contribute to it come from the body-wall, the lingual mass, and the pharynx. Anteriorly to the gill-sacs it resembles a sinus rather than a vein. In the diagram for *Bdellostoma* already referred to, the anterior part of the right cardinal

sinus is shown to communicate with the right jugular—indeed, to form the anterior part of it; but there is no reason to suppose that that is the case in *Heptatrema*.

When the right jugular of *Heptatrema* gets as far back as the gill-clefts its ventral position becomes more pronounced, as it has to pass below the incurrent branchial tubes. After passing the posterior end of the lingual mass it receives a vein that serves a considerable part of that mass, especially the left side. This may be referred to as the anterior lingual vein. There next enters a vein formed by the union of a left jugular and another vein from the lingual mass. This latter vein, which may be called the posterior lingual vein, is formed by two veins, one from the lower and right portions of the mass, the other from its upper portion. The left jugular vein is formed by two somewhat slender parallel branches lying below the incurrent tubes of the left gill-sacs. They unite 1·5 cm. before the posterior lingual vein is reached. After the vein formed by the union of the left jugular and the posterior lingual has entered, the combined jugular vein passes backward towards the heart. It receives the inferior jugular, a median vessel of considerable size. This vein is itself formed by the union of two veins running in the ventral body-wall below the lingual mass. After entry of the inferior jugular the jugular trunk passes to the posterior end of the sinus venosus, which it enters in close conjunction with the right hepatic vein.

Anterior Cardinal System.—The right anterior cardinal sinus starts beside the notochord at the base of the cranium. It runs backward in the body-wall until it comes abreast of the first gill-sac; then it tends towards the middle line, coming to lie beside the dorsal aorta, which, from the fifth gill-sac backwards, lies between it and the left anterior cardinal sinus. It receives many lateral veins. It ends in the portal heart. No part of it communicates with the sinus venosus.

The left anterior cardinal sinus commences in a position corresponding to that of the right. It early receives a large branch from below and beside the pharynx. This suggests that the anterior part of the left jugular may perhaps join the sinus. Posteriorly the left anterior cardinal sinus joins with the posterior cardinal trunk to enter the sinus venosus.

Posterior Cardinal Sinuses, Right and Left.—A median sinus originates just below the notochord in the tail. A right sinus presently separates from this, runs parallel to it for a little way, and rejoins it. This may be repeated once or twice. Finally the two sinuses are well established, and communicate with each other by several wide connecting branches below the dorsal aorta. As the sinus venosus is reached the right sinus gives off a small branch, which crosses the left sinus and runs to the portal heart. The right sinus then joins the left, and the combined trunk, with the left anterior cardinal sinus, joins the sinus venosus.

Segmental veins running from the body-wall enter the corresponding posterior cardinal sinus. Usually there is one such vein to two myomeres. Sometimes the renal vein running from a glomerulus enters one of these segmental veins, but more often it runs direct to the posterior sinus of its side. The renal veins leave the glomeruli on the ventral aspect. The segmental veins pass over the nephridial system dorsally.

Supra-intestinal Vein.—The supra-intestinal vein runs forward from near the termination of the intestine. It ends full in the portal heart.

Subintestinal Vein.—Veins from the anterior ventral part of the intestine unite to form a short subintestinal vein. The veins upon the surface of the gall-bladder unite to form a cystic vein which joins the subintestinal. The subintestinal vein then enters the right portal vein. It does not carry blood through the liver direct to the sinus venosus, as stated by Goodrich (*loc. cit.*) for Myxinoids generally.

The portal heart receives blood from three sources — the supra-intestinal vein, the right anterior cardinal sinus, and the right posterior cardinal sinus; while into the right portal vein there flows the sub-intestinal. The portal vein, on leaving the portal heart, forks, right and left veins passing to the corresponding lobes of the liver. These branches enter the liver on the lower (concave) surface.

EXPLANATION OF PLATES.

Plate XVI.

Fig. 1. Diagrammatic representation of the circulatory system.

Fig. 2. Part of the dorsal vessels and the nephridial system, from the dorsal aspect.
- *a.* Renal veinlet running from the dorsal aspect of a glomerulus to a segmental vein in the body-wall.
- *b.* Segmental artery sending branches to two glomeruli.

Plate XVII.

Fig. 1. The efferent branchial vessels and the anterior part of the dorsal aortic system, from the dorsal aspect.

Fig. 2. The afferent branchial system, from the ventral aspect.

Fig. 3. Right afferent branchial vessels, from the right side.

Fig. 4. Anterior part of post-cardinal system, showing connection of right sinus with portal heart.

Fig. 5. The jugular system, dissected from ventral aspect.

a.l.	Anterior lingual vein.
at.	Atrium.
d.a.	Dorsal aorta.
e.b.t.	Excurrent branchial tube.
ef.br.	Efferent branchial tube.
g.s.	Gill-sac.
i.	Intestine.
i.j.	Inferior jugular vein.
i.b.t.	Incurrent branchial tube.
j.t.	Combined jugular trunk.
l.	Lingual trunk.
l.a.	Left division of anterior aorta.
l.a.c.	Left anterior cardinal sinus.
l.h.	Left hepatic vein.
l.j.	Left jugular vein.
l.n.	Left nephridial system.
l.p.c.	Left posterior cardinal sinus.
l.pt.	Left branch of portal vein.
l.v.	Left division of ventral aorta.
m.a.	Median division of anterior aorta.
oes.d.	Oesophageo-cutaneous duct.
p.l.	Posterior lingual vein.
ph.	Pharynx.
pt.ht.	Portal heart.
r.a.	Right division of anterior aorta.
r.a.c.	Right anterior cardinal sinus.
r.c.	Communicating branch from right posterior cardinal sinus to portal heart.
r.h.	Right hepatic vein.
r.j.	Right jugular vein.
r.n.	Right nephridial system.
r.p.c.	Right posterior cardinal sinus.
r.pt.	Right branch of portal vein.
r.v.	Right division of ventral aorta.
s.a.	Segmental artery.
s.i.	Supra-intestinal vein.
s.v.	Sinus venosus.
sb.i.	Subintestinal vein.
sg.v.	Segmental vein.
spl.a.	Splanchnic artery.
v.	Ventricle.
v.a.	Ventral aorta.

Fig. 1.

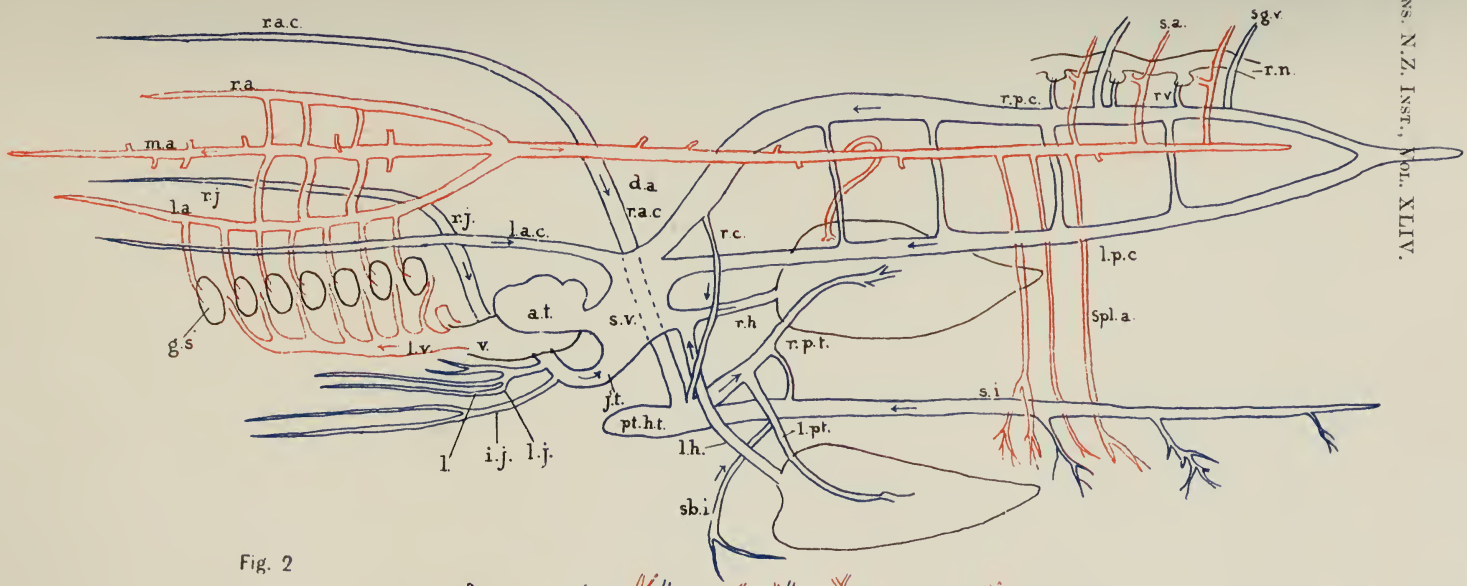
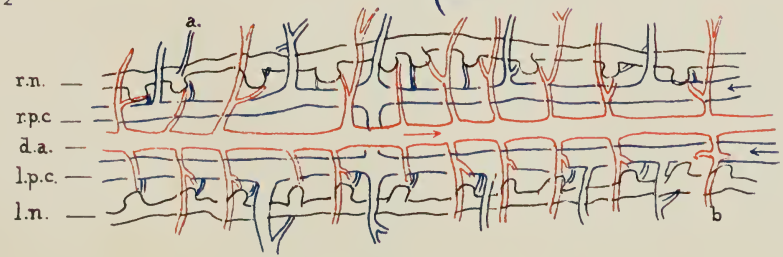


Fig. 2



HEPTATREMA CIRRATA.

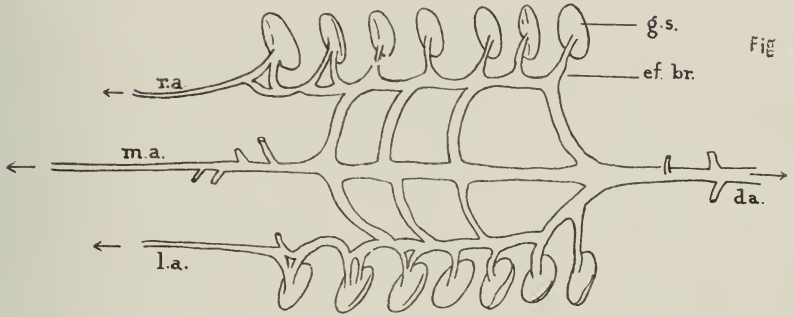


Fig. 1.

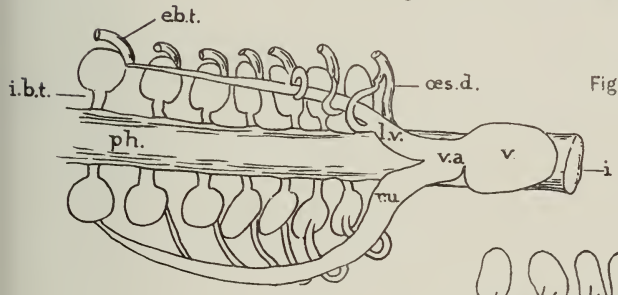
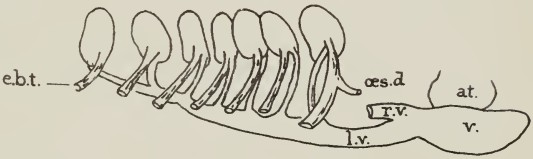


Fig. 2

Fig. 3.



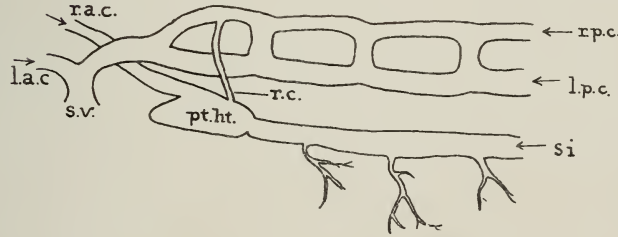
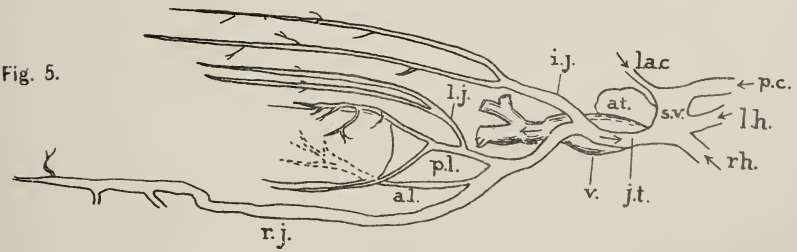


Fig. 4.

Fig. 5.



HEPTATREMA CIRRATA.

ART. XXVII.—*Notes on Wellington Physiography.**

By C. A. COTTON, Victoria College, Wellington, New Zealand.

[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

Plates XVIII–XXI.

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INTRODUCTION.

IN the preparation of these notes a detailed examination has been made only of the district lying to the west of Port Nicholson, which for convenience will be referred to as the Wellington Peninsula. By means of hasty traverses and observations made from a distance, however, it has been possible to reach general conclusions which, the writer believes, hold true for the whole of the district represented in the locality-map (fig. 1).

STRUCTURE.

With the exception of a few small patches of Recent sands and gravels occurring as beaches and river-flats, the rocks are a single series of sandy argillites and fine- and coarse-grained greywackes.† They are closely folded in a complex manner, but, owing chiefly to the unfossiliferous character of the rocks, the structure has not yet been unravelled. On any cross-section rapid changes in the direction of dip are the rule, but the attitude of the strata is so much more nearly vertical than horizontal that as far as their effect on topography is concerned they may be regarded as vertical. There has been no folding of any consequence in more than one

* When this paper was written the writer had not seen the criticism of Bell's paper by W. M. Davis in the Bulletin of the Am. Geogr. Soc. (vol. 43, No. 3, 1911, p. 190). Had he read that article earlier he would have been able to profit by several valuable hints given by Professor Davis.

† This thick, unfossiliferous series is correlated on lithological grounds with the Maitai system of New Zealand geologists, which, according to Marshall ("New Zealand," Handbuch reg. Geol., 7 Band, 10 Abt., p. 35, 1911), is of Trias-Jura age. The period of folding is believed to be late Mesozoic.

direction. In other words, the strike is reasonably constant in direction, being very generally N. 15° E., but varying locally from N. to N. 30° E.

The rocks of the series are of very variable strength, the weakness of some bands being due, apparently, in great part to their shattered nature. The argillites are invariably traversed by innumerable joints, and so also are the greywackes as a rule, but in places they are unjointed except on a large scale. The greywackes with few joints are very strong, forming some of the highest ridges and peaks. They weather spheroidally, and, when broken, present an appearance similar to that of an even-grained igneous rock. The shattered greywackes have in some places been rendered equally strong by the deposition of interlacing quartz veins filling the joint-planes.

Corresponding to the regular strike and the steep dip of the strata and their varying strength, there is a well-marked arrangement of ridges and valleys parallel to the strike. This may easily be recognized on a map, and in the field it is found to be the dominant feature of the topography. In fig. 1 the straight and parallel courses of the Orongorongo and Wainuiomata are especially noticeable. Parallel to these the entrance to Port Nicholson and the Evans Bay – Lyall Bay depression will be noted. On the Wellington Peninsula itself (see also fig. 2) one continuous valley, occupied by the Karori, Makara, and Ohariu Streams, is well marked. The position of another is indicated by the settlements of Karori and Khandallah; it continues southward some distance, and its northward continuation is the Porirua Valley. Even the high bluff of Cape Terawhiti is almost cut off from the neighbouring land by a deep north–south valley.

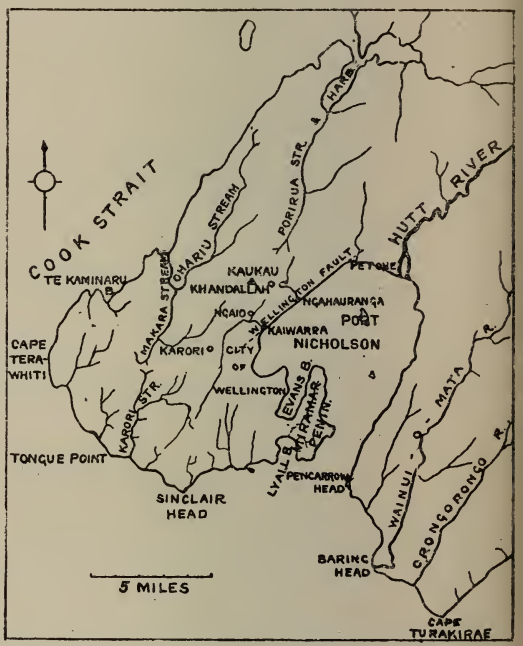

FIG. 1.—LOCALITY-MAP OF THE WELLINGTON DISTRICT.

LAND FEATURES.

The adjustment of stream-courses to structure, an arrangement which, with exceptions that will be noted, has been retained by existing streams, points to prolonged exposure to subaerial denudation for the duration of at least one nearly completed earlier cycle of erosion. The existing topography is composite, and has been developed during an uplift of at least 800 ft., and perhaps of 1,000 ft. or more. The amount of uplift seems to have been nearly uniform, although probably not quite uniform, over the area studied. During the uplift pauses occurred, some of which

were long periods of standstill. Further complications have been introduced by the subsidence of a block—Port Nicholson and the low-lying peninsula to the south of it (fig. 1)—resulting in piracy and obliteration of earlier topography in the high-standing block by vigorous new streams. The topography of a portion of the high-standing block unaffected by this

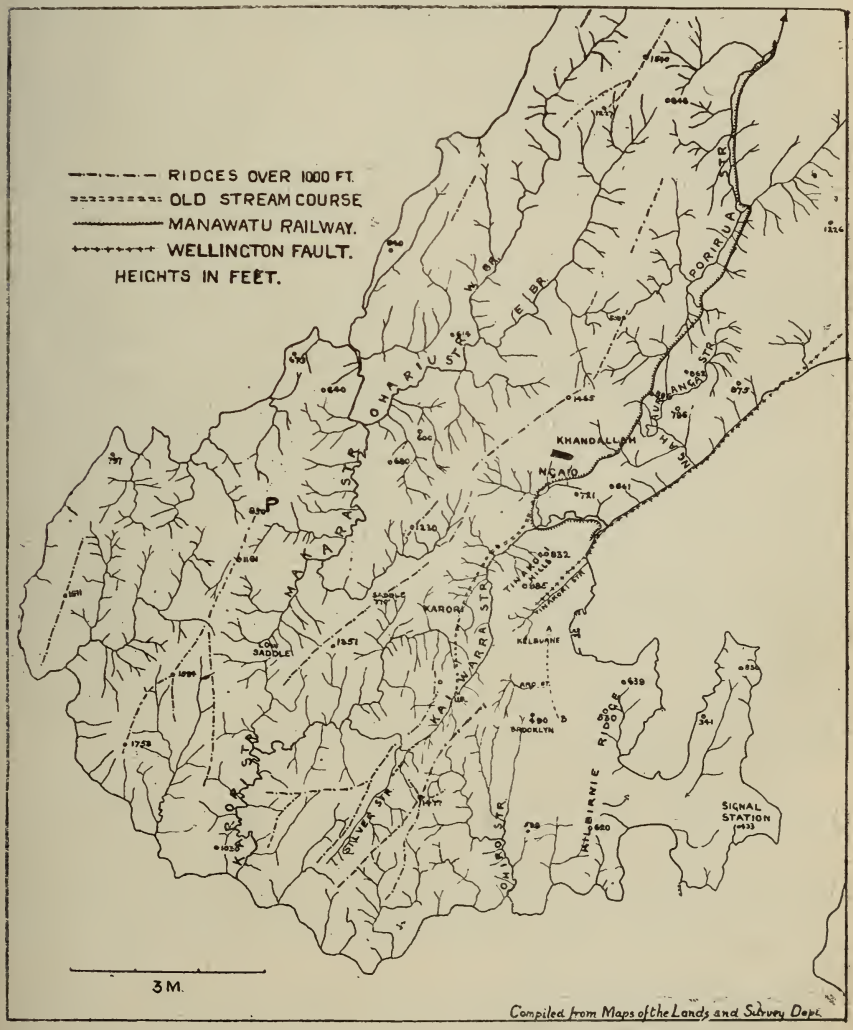

FIG. 2.—STREAMS AND RIDGES OF THE WELLINGTON PENINSULA.

complication may be studied first. As a typical area may be taken that to the west of the north–south divide on which the peak Kaukau stands (fig. 1).

The relief in this area is moderate to strong, as may be gathered from fig. 2, the ridges in parts rising to 700 ft. or 800 ft., and in other places

to over 1,000 ft., while a few peaks reach to 1,500 ft. and more. The texture of dissection is medium to fine.

Cycles of Erosion.

All the forms recognized appear to be due to stream-action alone. Three sets of forms are recognized, corresponding to different positions of base-level, and it is possible that forms are present corresponding to other pauses in the movements of uplift. It is evident that such pauses did occur, for remnants of coast platforms are found, in places, one above another (see p. 255). Shortness of a period of standstill during which erosive processes work is not in itself a reason why the period should not be dignified with the name of "cycle." Huntington and Goldthwaite* have pointed out the analogy between the term "cycle" applied to an erosion period and the term "life" applied to the period of existence of an organism. "Life in one signification is the complete existence of a normal organism during which it passes from infancy, through youth, maturity, and old age to death. The life of man in this sense is seventy years. In another sense life is merely the actual period of existence of any specific organism. An animal whose life in the first sense of the word is fifty years may die the day that it is born, but nevertheless we say that it has finished its life. A cycle in the first sense is ideal and can never be realized, since infinite time would be required to reduce any land-mass to the condition analogous to death—that is, to a plain at absolute base-level. In the second sense any region that is subjected to erosion during a definite period, no matter how short, passes through a cycle and can be described in terms of age and development." The term "chapter," proposed by Davis† for an unfinished cycle, has not come into general use. A number of such brief cycles, corresponding to pauses during the earlier part of the period of uplift in the Wellington district, may have left traces on the topography not yet obliterated, and the number of nearly flat-topped ridges of varying height which lie spread out to the west of Kaukau Peak suggests that in the future, with detailed work and accurate mapping, some at least of them may be recognized with certainty. The writer, however, feels justified at present in grouping the observed features as belonging to only three cycles.

The earliest cycle of which a record is preserved by existing topographic features will be called the Kaukau cycle. Base-level stood perhaps 800 ft. or 900 ft. higher than at present.

To the next, or Tongue Point, cycle belong most of the broad features of the landscape as seen from a high point of view. Base-level stood about 250 ft. higher than at present, and during the cycle the most extensive of the elevated coastal platforms, including that at Tongue Point, were cut (see p. 255).

It was between the Kaukau base-level and the Tongue Point base-level that other pauses occurred that are mentioned above. They were, no doubt, brief, and the Tongue Point cycle itself was of relatively short duration. It is, however, of importance on account of the very recent date at which it was interrupted.

There is, lastly, the present cycle, with present sea-level as base-level.

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* Bull. Mus. Comp. Zöol., Harv., vol. 42, No. 5, 1904, p. 239.

† "Physical Geography as a University Study," Journal of Geol., 1894, p. 66.

Forms of the Kaukau Cycle.

Kaukau* Peak (1,465 ft.) may be taken as a sample of a form belonging to the first, or Kaukau, cycle. An area of about 50 acres at the summit presents the appearance of mature topography, with gently rounded outlines, which abruptly give place to precipitous slopes, rocky crags, and torrent-ravines, forms of the next cycle. The small, gently graded valleys of the summit are transformed within a few yards into torrent-courses with rock beds and steep rock walls. There is no difference of rock-strength to account for the change, but summit and sides alike are composed of the most resistant type of strong greywacke, traversed by few joints.

In fig. 3 the slopes of the summit of Kaukau are seen in the foreground. The surface is littered with blocks of the greywacke, weathering in the manner generally regarded as characteristic of igneous rocks rather than of sedimentary rocks.

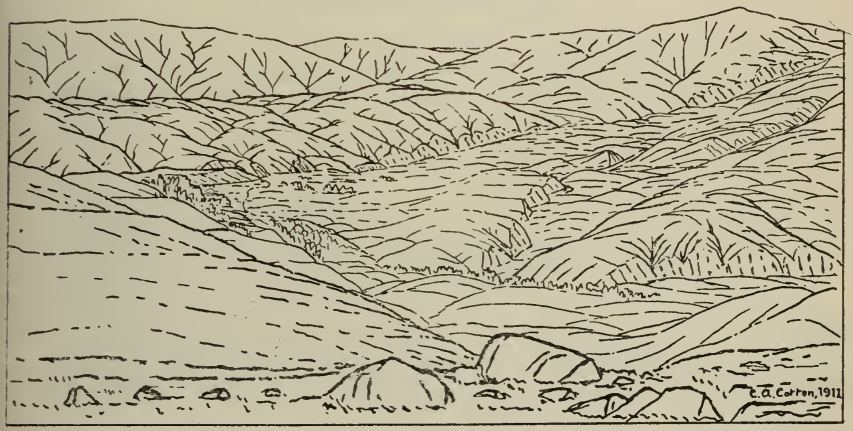

Fig. 3.—View of the East Branch of Ohariu Stream, looking Northward from the Summit of Kaukau Peak.

A graded reach, at its lowest point 250 ft. above sea-level, and incised about 50 ft. below the graded valley-floor of the earlier cycle.

Little is left of the surface belonging to the Kaukau cycle, and perhaps the most extensive remnant is a tableland nearly a square mile in extent, standing 950 ft. above sea-level, which exists on the divide west of the Makara Stream. In fig. 2 it is marked P. It has an undulating surface of mature valleys and rounded spurs, appearing from a distance perfectly plane. It is bounded on all sides by the slopes of young ravines eating into it.

Many of the higher ridges show very similar topography, though no other is so nearly plane. From these observations it appears that during the Kaukau cycle the stage of maturity was reached, and that this nearly plane area, P, stood not far above base-level. The height of Kaukau and other peaks above it shows that the relief remained fairly strong.

It is not probable that this cycle was the one which began when the folded range first rose above the sea, for planation might be expected to

* Locally pronounced *Caw-caw*, and spelt on some maps *Kaka*.

be much more complete. The longitudinal drainage corresponding to the strike appears to have been established during the Kaukau cycle and a hypothetical earlier erosion period, for the adjustment of stream-courses to structure which has been preserved in later cycles points to prolonged denudation, and in rocks presenting but slight variation in hardness it is unlikely that anything like complete adjustment could be attained in a period as brief as that occupied by later cycles.

While some adjustments may have been completed in the Tongue Point cycle, there is no doubt that most streams in the initial stage of that cycle followed subsequent courses.

Owing to a peculiar set of circumstances, referred to elsewhere, the captures that have taken place during the present cycle have to some extent destroyed rather than completed the earlier adjustment. It is possible that some of these retrograde changes took place as far back as the Tongue Point cycle.

The Tongue Point Cycle.

The stage reached in the Tongue Point cycle was adolescence or early maturity. In the streams of the Makara-Ohariu system (fig. 2), for example, the stream-courses were graded, and the valley-floors occupied by

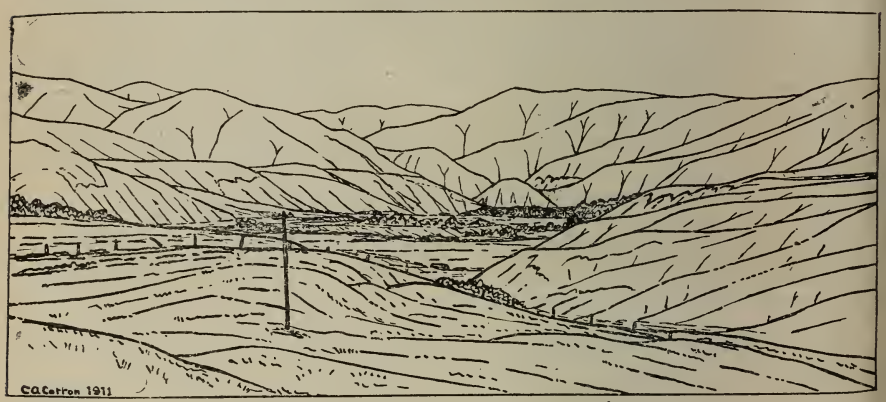

Fig. 4.—Graded Reach in the Makara Stream.

On the foreground and on right and left are benches of the flood-plain of the Tongue Point cycle.

broad flood-plains, of which abundant traces remain as benches along the sides of the valleys now trenched by the deep, young valleys of the revived streams, and scored across by the young ravines of insequent tributaries.

Fig. 4 represents the valley of the Makara. The sketch was made from a broad bench of the flood-plain of the Tongue Point cycle. Portions of this are seen also on the other side of the valley. In Plate XVIII, fig. 1, a view is given, looking southward, up the valley from about the same point. It shows the elevated flood-plain of the Tongue Point cycle on the left, and in the centre the later, steeper-grade flood-plain developed by the stream, in a graded reach, in the present cycle. By lateral swinging and migration of meanders on this flood-plain the stream has cut back the valley-slope on the right to a steep scarp.

Fig. 1.—View looking Southward up Makara Valley from Surface of Flood-plain of Tongue Point Cycle.

Fig. 2.—The Eastern Shore of Miramar Peninsula, showing Raised Rock Platforms.

Fig. 3.—Elevated Coast Platform at Tongue Point.
The covering of beach-worn gravel is seen in the slip on the right.

Fig. 1.—The South Coast, East of Sinclair Head.

Fig. 2.—Scarp of the Wellington Fault seen from Petone.

Fig. 3.—Facets at Petone Railway-station.

Fig. 4.—"Long Valley": View from Ngaio towards Karori.

Divides in the Tongue Point cycle have in some cases been reduced to a fairly low altitude. Where they stand only 600 ft. to 800 ft. above present sea-level they have been rounded and their slopes graded, and rock outcrops are few. Higher-standing ridges are more rugged, with rock outcrops and sharpened summits, except where they are flat-topped, and forms of the Kaukau cycle remain.

The broad upland features in fig. 3 belong to the Tongue Point cycle. The Ohariu and other streams, however, shown in the figure have been revived, and reaches have been graded and widened with the formation of flood-plains. These belong to the present cycle.

The Present Cycle.

Forms of the present cycle comprise the steep lower slopes of valley-sides and the flood-plains developed along portions of the courses of the larger streams. The Makara-Ohariu system may still be retained as an example (figs. 3 and 4). The streams are not yet graded throughout their length, but a number of flat-floored graded reaches have been worked out, the flood-plains of which are extensive enough to be cultivated. These reaches are invariably strictly parallel to the strike of the rocks. The long graded reach of the east branch of the Ohariu shown in fig. 3, for example, is incised only to a depth of about 50 ft. below the flood-plain of the earlier cycle. Where it turns sharply to the south-west its bed is 250 ft. above the sea. It then follows an entrenched meandering course in a young gorge diagonally across the strike, and falls 240 ft. in two miles.

The present cycle, therefore, cannot be said to have passed its early youth.

THE PORT NICHOLSON AREA.

East of the ridge upon which Kaukau Peak stands there is a complicated topography, the result of subsidence of the Port Nicholson block. The writer is inclined to believe that either the original boundaries of the subsided block were broad flexures rather than faults, or, on the other hand, the original subsidence took place so long ago that topographical evidence of faulting has been obscured by subsequent denudation. The numerous fault-lines suggested by Bell* run parallel with the strike, and for this reason old faulting along these lines would not be rendered recognizable by revival of erosion.

The north-western portion of Port Nicholson was, however, undoubtedly let down by faulting at a relatively recent date, for along the north-western shore of the harbour there is a clearly defined fault-scarp (see fig. 9). Faulting along this line (the Wellington fault, see p. 257) took place perhaps along with, but more probably after, the submergence of the main portion of the Port Nicholson block. The fault and, in general, the subsidence of the whole block have provided the drainage of the whole area with a much shorter and therefore steeper descent than it formerly had. Two of the active torrents which descended the steep slope quickly succeeded in cutting back so as to tap the drainage of a broad mature valley, the floor of which stood 500 ft. and more above present sea-level (see "Changes in the Drainage of the Karori-Khandallah Valley," p. 262).

* Trans. N.Z. Inst., vol. 42, 1910, map and section, pp. 537, 539.

The downthrown area is partly covered by the harbour of Port Nicholson, which occupies the seaward portion of the drowned valley of the Hutt River, and also portions of some smaller valleys which appear to have been tributaries of the now dismembered Hutt. The date of subsidence, whether before or after the beginning of the present cycle in the high-standing block, has not been deduced with certainty from the outlines of the partly submerged Miramar Peninsula and adjoining ridges. Mature slopes are now the rule, and younger slopes, if they have existed, are submerged. The deep water that is to be found over the greater part of the harbour (fig. 5) is an indication either of a great amount of sinking of the submerged block, or, on the other hand, of the recent date of the subsidence. Enormous quantities of waste must have been delivered to the harbour by the streams which enter it along the Wellington fault and have cut their gorges in the post-faulting period. Since tidal currents are insignificant to prevent silting, the range being only 3 ft. to 4 ft., the existing freedom from shoals must therefore be taken as an indication of great initial depth and large initial capacity of the basin. The Hutt River, entering at the northern end, has already built an extensive delta of sand and gravel, but the enormous loads of waste tipped over the fault-scarp by the Kaiwarra and the Ngahauranga have not been revealed even by the uplift of 5 ft. which took place in 1855 (see p. 259). Fig. 5, which is a rough contour-map of the harbour-floor, gives an idea of the manner in which sediment is being evenly spread out as a flat layer in the deep water of the harbour. It will be noted that the shallowest water is near the entrance, where a dredge is at work lifting sand and shells. The shallow water at the entrance appears to be due to the accumulation of waste broken by wave-action on the outer coast.

Fig. 5.—Port Nicholson.

Depths in fathoms below L.W.S. Data from the "New Zealand Nautical Almanac," 1910.

The material furnished by marine erosion on the outer coast has completely blocked one former entrance to the harbour. A bar of sand, or tombolo,* has converted a former island into a peninsula (Miramar Peninsula), and divided a former channel into two bays (Lyall Bay and Evans Bay). A good example is here afforded of the manner in which a coast-line is straightened (regularized) by wave-action, as described by Davis† and by de Martonne.‡

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* See F. P. Gulliver, "Shore-line Topography," Proc. Am. Ac. of Arts and Sci., vol. 34, No. 8, 1899, p. 189.

† "The Outline of Cape Cod," Proc. Am. Ac. of Arts and Sci., 1896; reprinted in Geogr. Essays, 1909, p. 690.

‡ "Géographie physique," p. 685; Paris, 1909.

The diagram (fig. 6) is an attempt to explain graphically the evolution of Miramar Peninsula. It does not appear that the channel thus blocked had ever the importance of the present entrance, which has from the first been the main channel, and is the continuation of the Hutt Valley.

Mr. Elsdon Best has drawn the writer's attention to an authentic Maori tradition, first put in writing about 1850, which relates some episodes in the history of the locality some seventeen generations ago (*i.e.* about the end of the fifteenth century). It appears that before that period Evans Bay and Lyall Bay were connected by a channel, which was probably kept open by the tide through the growing sand-bar. The tradition relates that, when a party of Maoris had retired to the island (Miramar Peninsula is clearly indicated) with all the available canoes, another party, pursuing them, were compelled to build rafts to effect the crossing. An account is given also of an event which appears to have been an earthquake accompanied by elevation of the land. By that movement the channel was finally closed.

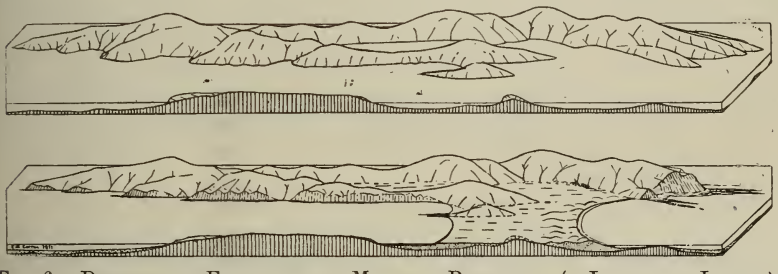

FIG. 6.—DIAGRAM OF EVOLUTION OF MIRAMAR PENINSULA (A LAND-TIED ISLAND).

In the lower diagram Evans Bay (opening to Port Nicholson) is on the left, and Lyall Bay (opening to the ocean) on the right. Spurs running down both to Evans Bay and to the ocean have been cut back by marine erosion, and rock platforms indicating their former area have been exposed by a recent movement of elevation. These are much more extensive at the seaward end, but even on the shore of Evans Bay a moderate amount of cutting has been done by the waves raised on the waters of Port Nicholson by the prevailing north wind. The sand-bar joining the island to the mainland must have been formed at an early stage, for the spurs running down into it have been almost completely protected from marine erosion. The upper diagram is a restoration of the initial form of Miramar "island."

The case of Miramar Peninsula is therefore one where island-tying has been assisted by a slight movement of the land.* It seems probable that without a slight movement of elevation a shallow channel would always have been kept open through the bar by the tide.

In a quaint paper by Crawford,† entitled "Port Nicholson, an Ancient Fresh-water Lake," the view was advanced that the present entrance had been opened quite recently by the sea, and that over a dam of boulders in the Evans Bay–Lyall Bay channel the waters of a fresh-water lake formerly escaped and cascaded down to join the "great Cook Strait river."

The small channel appears to have been formed by the drowning of two small streams, one flowing north and the other south, separated by a low divide which is evidently not deeply buried, for the spurs running down from opposite sides into the sand-bar are not widely separated.

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* See Gulliver, *loc. cit.*, p. 200.

† Trans. N.Z. Inst., vol. 6, 1874, p. 290.

From the above description and from fig. 6 it will be gathered that the coast-line of the downthrown Port Nicholson block is a normal drowned coast, passing through the normal cycle of littoral erosion which has reached the early mature stage. It is thus in strong contrast with the coasts of the neighbouring high-standing blocks described in the next paragraph.

Coast Features.

The Cliffs.

The actual outline of the coast of the high-standing block is the result of marine erosion working back from an earlier coast-line almost certainly bounded by fractures. This seems to be the only view tenable, for the amount of marine erosion necessary to cut back the present coast, with its line of lofty cliffs, from a coast-line of any other form would be enormous, and seems out of the question when a comparison is made with the recently revived condition of the land-drainage. There is no evidence of a slow sinking of the land such as would be required to keep up the activity of wave-action on a receding coast. The depths of hundreds of fathoms recorded within a very few miles of the southern coast indicate that the block to the south has sunk, and the closeness of the hundred-fathoms line to the western coast indicates subsidence in that direction.

The hypothesis of a fracture-bound coast gains further support from the relation of the coast-line to stream-courses on the land-surface. The Silver Stream (see fig. 2) rises at a height of 1,000 ft. only three-quarters of a mile from the southern coast, and flows northward. The western coast also cuts in along a north-easterly line, making an angle with both the strike of the rocks and the stream-courses. The Ohariu Stream, on the north-west, like the Silver Stream on the south, rises almost on the coast, and flows inland.

Cook Strait, which bounds the Wellington Peninsula on the west and south, has been generally regarded as the result of faulting since the time of Hochstetter, whose views were followed by Hutton and more recently by Park. Hochstetter's early view* was that one island had been thrust laterally past the other—that is, that the movement was of the nature of a "flaw." As has been pointed out by Suess, however, Hochstetter's later view† was that Cook Strait owed its origin simply to the subsidence of a mountain block or blocks, and he was aware that the continuation of the North Island ranges is to be found on the same line of strike in the Kaikoura Mountains of the South Island. This relation is brought out by Marshall's‡ maps of physical features of New Zealand.

The west and south coasts present similar features. The only projecting points are those composed of resistant rock, usually bands that are hardened with interlacing veins of quartz, filling joints. The intervening, less resistant rock bands recede as bays of gentle curvature, bounded by imposing cliffs. The larger streams emerge at beach-level, in gorges revived and steepened by the rapid recession of the coast,

* Lecture on the Geology of the Province of Nelson, 1859, reprinted in "Geology of New Zealand" (Auckland, 1864), p. 106: see also Park's "Geology of New Zealand," 1910, p. 262.

† "Reise der 'Novara,'" 1864, Geol. vol. 1, p. 2.

‡ *Loc. cit.*, pp. 10, 11.

while the smaller ravines are truncated, appearing as notches, hanging at various heights on the cliffs. Wherever the lower reach of a stream makes a small angle with the coast the spur separating it from the sea has the form of a razorback, due to lateral cutting by the stream on one side and the sea on the other.

The coast-line is, therefore, a continuous line of stupendous cliffs, rising in places on the south coast, where the coast-line cuts across the highest ridges, to 700 ft. or 800 ft. In Plate XIX, fig. 1, a portion of the south coast is seen eastward from Sinclair Head. The triangular cliff-facet photographed is 400 ft. or 500 ft. in height. To the west the height of the cliffs increases.

The Coast Platforms.

Along parts of the coast no relics remain of elevated platforms cut by the sea during pauses in the movement of uplift. They have either been completely cut away by the waves or cut off by faulting along new lines of fracture. At other places extensive shelves remain. The most prominent begins at Tongue Point and extends some distance westward (see fig. 7, and Plate XVIII, fig. 3). The shoreward edge of this shelf appears to indicate

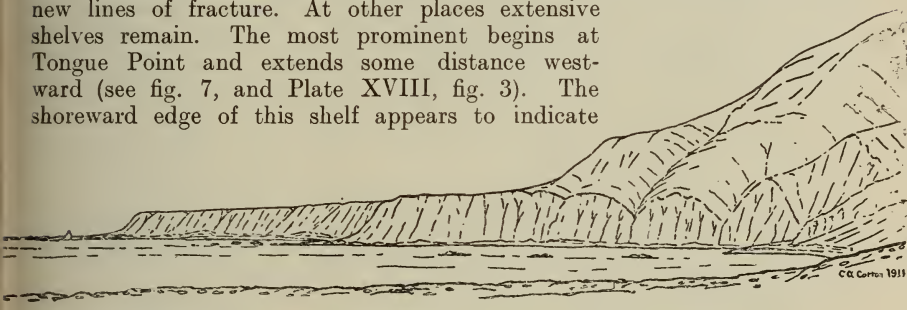

FIG. 7.—THE ELEVATED COAST PLATFORMS AT TONGUE POINT.

the base-level at the time when the streams of the district developed the greater part of the existing upland topography. For that reason the writer has named that erosion cycle the Tongue Point cycle.

The height of the shelf at its inner edge at Tongue Point is 240 ft. Its slope seaward is at first 10°, but rapidly decreases, and at the end of Tongue Point, where the shelf is half a mile broad, it runs gently out at an angle of 2° or 3°.

The upper surface of the shelf is covered by a veneer, 6 ft. or 8 ft. in thickness, of gravels similar to those of the present beach. They vary irregularly from beds of coarse roughly rounded gravel and boulders, material similar to what is being supplied to-day in large quantities by the smaller streams, to layers of fine flattened discs of beach-shingle varying from the size of a threepenny-piece to that of a penny. A layer of the coarser gravel is seen on the right in Plate XVIII, fig. 3.

The varying height of the outer scarp of this marine terrace as seen from the sea is clearly due mainly to the varying breadth of the portions that have withstood the action of the sea, the seaward slope of the shelf being regarded as nearly constant. At the extremity of Tongue Point it comes down to 170 ft. Beyond the next creek to the west, where there is a well-preserved but narrower remnant, the outer edge bounded by the present scarp is, as might be expected, higher. It is evidently this apparent variation in the height of the shelf that

led Park* to remark that he had satisfied himself "that it was not an uplifted marine platform of erosion." It may be remarked that a section, even on a vertical plane through a coastal platform, parallel to the average direction of the coast must not be expected to yield a perfectly horizontal crest. It ought to show a convex crest opposite to bluffs, where the old coast approaches it, and a concave outline opposite bays, where the old coast recedes. To this initial irregularity there may be added slight variations in the amount of subsequent uplift. Remnants of this terrace extend nearly to Cape Terawhiti, and it may be seen also at Te Kaminaru Bay, on the western coast.

There exists also a higher shelf, which was examined at Tongue Point. It may be seen in fig. 7. Its height is about 450 ft., and, like the lower shelf, it is covered with a layer of water-worn pebbles. Its width at the point examined had been reduced by the cutting of the lower shelf to about 50 yards.

At Baring Head, on the coast south-eastward of Pencarrow Head, at the entrance to Port Nicholson, similar shelves occur,† and again at Cape Turakirae. They may be seen from the deck of a steamer entering Port Nicholson. The sketch, fig. 8, represents them as seen from

Fig. 8.—The Elevated Coast Platforms between Pencarrow Head and Baring Head, as seen from the Signal-station on Miramar Peninsula.

Pencarrow Head in centre, Baring Head on right.

the signal-station on Miramar Peninsula. They are cut through by the revived Wainuiomata. The writer has not examined these platforms closely, but believes they correspond in a general way to those at Tongue Point, the sunken area of Port Nicholson lying between. The highest platform at Baring Head appears to be about 500 ft. above sea-level. It has been shown above that the general outlines of the coast appear to be determined by subsidence of land blocks, but, on the other hand, it cannot be assumed that the whole of the uplift of which we here have evidence is differential uplift along these lines of fracture. At many places on the New Zealand coast marine platforms and raised beaches are known, indicating uplift of varying amount.‡ McKay has recorded Recent shells on a beach at a height of 500 ft. at Amuri Bluff, about eighty miles south-west of Wellington. If this beach can be correlated with the highest shelf at Wellington it may indicate that the stretch of land between has moved as a whole. The latest movement, which took place in 1855, and was described by

* Trans. N.Z. Inst., vol. 42, 1910, p. 586, and fig. 3.
† See Park, *loc. cit.*, p. 585, fig. 2.
‡ See Marshall, *loc. cit.*, p. 31.

Lyell,* affected both sides of Cook Strait. It was, however, a tilt to the west, which depressed the western shore of the strait and elevated the Wellington side as a whole—that is, the area shown in fig. 1—by an amount varying from zero on the north-west to about 9 ft. on the south-east. The raised beaches of the Wellington coast which owe their elevation to that movement have been described and figured by Bell.† They may be seen also in Plate XVIII, fig. 2, and Plate XXI, fig. 2. Both views are of parts of the eastern shore of Miramar Peninsula.

FIG. 9.—THE SCARP OF THE WELLINGTON FAULT AS SEEN FROM KELBURNE.
The mouth of the Kaiwarra is a little to the left of the centre, and the mouth of the Ngahauranga is on the right.

There is some evidence that this tilt is a continuation of an earlier tilting movement in the same direction, the axis of the movement lying a little to the west of Wellington. On the south-east a series of very fresh raised gravel beaches at Cape Turakirae, the highest being 90 ft. above the sea, are mentioned by Aston.‡ On the north-west there appears to have been a downward movement of small amount subsequently to the general movement of elevation the proofs of which have been given. This movement, which has drowned the lower reach of the Porirua Stream, does not appear to have been more than 30 ft. or 40 ft. The stream had previously developed a broad strip of flood-plain, and this has been drowned to a distance of about a mile and a half from the sea. At Porirua there appears to have been little or no movement either up or down in 1855. Raised rock platforms similar to those at Wellington are not found. This agrees with the accounts of eye-witnesses given in substance by Lyell.§

THE WELLINGTON FAULT.

The Fault-scarp.

The following account may serve to supplement the "proof of the great fault along the western side of Wellington Harbour" given by Bell.‖ In fig. 1 the line of faulting is indicated as "Wellington fault" (see also fig. 9, a sketch of the fault-scarp as seen from Kelburne, and Plate XIX, fig. 2, a photograph from Petone). For the length of this line, about six miles, the Port Nicholson depression is bounded by an abrupt scarp with a base-line almost perfectly straight, the departure from perfect alignment consisting of two very gentle curves, concave towards the shore, separated by a similar convex curve of very

* "Principles of Geology," 10th ed., 1868, vol. 2, p. 82.
† Trans. N.Z. Inst., vol. 42, 1910, p. 538, and pl. 41 and 42.
‡ B. C. Aston, this volume, p. 208.
§ *Loc. cit.*
‖ *Loc. cit.*, p. 539.

wide radius. The average direction of the base-line is N. 50° E. It makes a decided angle with the strike of the rock strata. Where road-cuttings have been made parallel with the line of the scarp, rock outcrops run up the face obliquely in one direction or the other, according to the dip of the beds. Sloping down to the even base at an angle of 55° is a flat and even face, separated into triangular facets by a number of ravines. The mouths of some of these ravines overhang the shore, as if a period or periods of standstill accompanied by erosion had separated periods of movement the last of which took place at a very recent date. There are, however, no traces of wave-cut shelves along the scarp such as one would expect if the movement had been one of elevation of the landward block. It would seem rather that the movement was altogether a subsidence of the harbour block. Clay terraces overhanging Tinakori Road, which were regarded by Bell* as beach deposits on a rising block, are clearly remnants of the floor of a mature valley which was cut across obliquely by the fault.

An alternative and perhaps the correct explanation of the hanging ravines on the fault-scarp is that the ravines were developed when the boundary of the Port Nicholson depression lay farther out, before the final movement on the plane of the Wellington fault. By the final faulting movement they would then be truncated. This hypothesis gains some support from the fact that tributaries of the larger streams, the Kaiwarra and the Ngahauranga, which cross the fault-scarp show evidence of recent revival.

Fig. 10.—Truncated Valley overhanging the Ngahauranga Gorge.

The line of the straight fence gives a cross-profile of the upper part of the valley.

These two larger streams have been sufficiently active to capture the drainage of a longitudinal valley at the back. The changes in their courses are described in a later paragraph (p. 262). Both streams in their lower reaches, where they cross the fault-scarp, flow in narrow, young gorges (see Plate XX, figs. 1 and 2).

Fig. 10, a sketch of a little valley truncated by the Ngahauranga, gives an indication of the depth to which the latter has incised its course below an older surface of moderate relief.

The Kaiwarra, which is the larger stream of the two, has graded its course, and for a distance of a mile from its mouth has worked out an extremely narrow strip of flood-plain (Plate XX, fig. 1). The Ngahauranga is not graded. A fall in its lower course is illustrated in Plate XX, fig. 2.

There is no doubt that both these streams are of extremely recent origin. Their lower courses are consequent upon the slope of the fault-scarp, or, at least, of the boundary of the Port Nicholson depression.

Next to the extremely young character of the streams the most important piece of evidence in favour of faulting is the abrupt manner in which the ridges separating them are terminated as a straight line of cliffs at the harbour side. If the theory of faulting is not entertained these must

* *Loc. cit.*, p. 539.

Fig. 1.

Fig. 2.

Fig. 1.—View looking up the Lower Gorge of the Kaiwarra towards Wadestown. The Kaiwarra is here followed by the Manawatu railway.

Fig. 2.—Fall in the Lower Gorge of the Ngahauranga.

Fig. 1.—Narrowed Spur in the Ngahauranga Valley.

Fig. 2.—Raised Beaches and Wave-cut Cliffs on the South-eastern Shore of Miramar Peninsula.

be regarded as having extended at least a mile out into the waters of Port Nicholson, enclosing between them the continuations of the present gorges; and the coast must have been cut back to a straight line by wave-action.

The problem may be attacked in two ways: (1.) Search for the rock platforms which should remain to indicate the former extension of the spurs. A glance at fig. 5 shows that these are absent, and that the deepest water of Port Nicholson comes close to this shore. Rock platforms, if they existed, ought to have been actually raised above water by the 5 ft. uplift of 1855, but for nearly the whole length of the scarp rocks are not exposed at low water more than 50 yards from the foot of the cliffs. (2.) Comparison with other parts of the coast-line where marine erosion has been more or less effective in cutting back the coast. The coast of the seaward end of Miramar Peninsula (fig. 6) may be considered. Here, indeed, bluffs have been cut back to the extent of a mile, as the exposed rock platform at their base shows, but the coast has by no means been rendered perfectly straight. Moreover, compared with its activity on the outer coast, wave-action within the harbour is extremely feeble. A safe comparison can therefore be made only with another stretch of coast within the harbour. When the eastern shore is examined it is found that wave-action has succeeded only in shaving off the ends of points. Fig. 11 represents the eastern shore as seen from the signal-station on Miramar Peninsula. Its irregular base-line may be noted on the maps, figs. 1 and 5. It should be noted that this side of the harbour is bounded by a strike ridge, and that no spurs of any magnitude run down from it. So a shore-line originally nearly straight has been rendered but little straighter by wave-cutting. Moreover, the increasing height of cliffs towards the harbour-entrance shows that the greater part of the work has been done by waves rolling in from the open sea. The western shore of the harbour, on the other hand, is affected only by waves raised on the harbour itself. The effect of waves raised within the harbour is seen on the shore of Evans Bay (on the left in fig. 6).

The conclusion reached is that the scarp bordering the harbour on the north-west, with its straight base-line, cutting at an angle across the strike both of the rock strata and of the drowned ridges to the south of it, with its faceted spurs and its steep-grade gorges, is the result of recent faulting. Fig. 9 may be compared with the sketches and photographs of the Wasatch Range given by Davis,* and also with the diagrams illustrating his theoretical discussion of the dissection of the face of a faulted block.†

Nature of the Movement.

The fact that the portions remaining of the scarp along the fault-line are inclined back at an angle of about 55° may indicate that the surface along which movement took place had that inclination. On the other hand, if the fault-plane were steeper the slope would quickly be reduced by slipping along the crest of the high block.

* W. M. Davis, Bull. Mus. Comp. Zöol., Harv., vol. 42, No. 3, 1904, p. 153, and pl. 4; and vol. 49, No. 2, 1905, fig. 2, and pl. 1, A.

† *Loc. cit.*, vol. 42, No. 3, 1904, figs. 6–9.

From the absence of slipped material along the base of the Wasatch Range, in Utah, Davis* argued that the slope of the spur-facets now found there gives the inclination of the plane of faulting. In the case of the Wellington scarp, however, it is uncertain whether a scree of slipped material exists or not beneath the water and silt of the harbour. Nor can the very even slope of the facets throughout the length of the scarp be taken as an indication that they represent the actual plane of faulting. Their slope appears rather to be "the angle of rest for the products of decay" of the material of which they are composed. The writer cannot agree with Bell† that the slope is steeper than the angle of rest. It is clear that many, if not all, of the clearly defined, sharp-edged facets owe their actual form to wave-action at their bases, the extent to which the scarp has been thus cut back being indicated by a narrow wave-cut platform at its foot. This, however, seldom reaches a width of 40 or 50 yards, and part of it may represent a levelled-off scree of slipped material. It is now almost entirely covered by the railway-embankment along the shore.

Reasons have already been given for believing that the actual movement has been subsidence of the block to the south-east (p. 258). It was assumed by Bell‡ that the faulting movement was one of block elevation and tilting towards the north-west, and the Porirua Stream was cited as an example of a stream flowing down the tilted back slope of the block. There is no doubt, however, that the Porirua followed its present course before faulting took place. It follows one of the old strike valleys. In the valley there is evidence of recent revival, but not such as would be required by a tilt of the magnitude assumed; it appears to be due solely to the general movement of uplift which has affected the Wellington Peninsula, although perhaps not everywhere by exactly the same amount. The drowning of the lower Porirua may be ascribed to a less-extensive later tilt of a much larger block of country (see p. 257).

Other Faults.

An origin by faulting is implied for some of the longitudinal features of the Wellington Peninsula by Bell,§ and the line of the Makara Valley is included by McKay‖ among "active faults and earthquake rents." The presence of many faults, and particularly of the last mentioned, is revealed in natural sections. The three faults which McKay¶ describes as "converging on . . . the capital of New Zealand" can be recognized, although it is difficult to see why they are to be regarded as the continuation of faults in the South Island. The stratigraphy of the district is too little known to allow an estimate to be made of the amount of movement on the fault-planes, and the period at which the main movement took place has not been ascertained. It can be confidently stated, however, for the whole of the area west of the Karori-Khandallah Valley that physiographic evidence of recent faulting is entirely lacking (see pp. 262–64). The boundaries of the subsided Port Nicholson block may next be investigated.

On the map of Port Nicholson given by Bell** there are indicated, in addition to the Wellington fault, five other fault-lines bounding the

* Bull. Mus. Comp. Zöol., Harv., vol. 42, No. 3, 1904, p. 158.
† *Loc. cit.*, p. 536.
‡ *Loc. cit.*, p. 539.
§ *Loc. cit.*, section, p. 539.
‖ "Reports of Geological Explorations, 1890–91," map, p. 1; Wellington, 1891.
¶ *Loc. cit.*, p. 19.
** *Loc. cit.*, p. 537.

downthrown area. It is probable that these lines are only suggestions, for on the accompanying section giving probable faults* two given on the map are omitted and another is introduced. As mapped they are nearly parallel to one another, and appear to coincide with the strike of the rocks. For those bounding on the east and west the longitudinal ridges of Miramar Peninsula and the Kilbirnie ridge to the west of it there appears to be no evidence. The elongation of each ridge is satisfactorily explained as corresponding to rock structure. Neither ridge has, on either side, a straight or gently curved base-line, but sprawling spurs are given off (see fig. 6). Both shores of Lyall Bay (figs. 1 and 6) directly facing the ocean to the south are bounded by cliffs. That these are not fault-scarps there is abundant proof in the extensive rock platforms at their bases, which were raised above the sea by the small uplift of 1855. These prove a former long seaward extension of the spurs. Where the tombolo (fig. 6) connects Miramar Peninsula to the mainland this has afforded protection from marine erosion, and the spurs run far out, that from Miramar Peninsula almost meeting that from the mainland. To the north of the tombolo in Evans Bay, on both shores, smaller scarps are found, fronted by less-extensive rock platforms than those of Lyall Bay, all evidently the work of the waves on Port Nicholson, the energy of which is very much less than of those of the open sea. They are, however, sufficiently powerful,

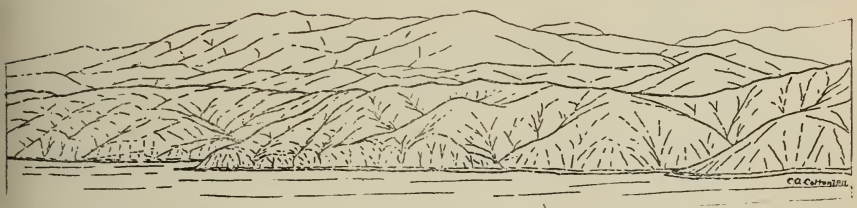

Fig. 11.—Eastern Shore of Port Nicholson, looking North-east from the Signal-station on Miramar Peninsula.

urged by the prevailing strong northerly winds, to account for the destruction of the relatively small bulk of the spurs and slopes, the removal of which has resulted in the present scarped shore.

Similar arguments can be used against the probability of a fault bounding the harbour on the east. The shore-line is fairly straight for several miles in the entrance, but the obvious reason for this is that it is the side of a low narrow ridge, without lateral spurs, between two straight valleys. The shore is subject to powerful wave-action, as it is not sheltered from waves entering the harbour-mouth, and marine erosion has been able, by the removal of quite a moderate amount of material, to cut a continuous line of cliffs.

Farther north, towards the head of Port Nicholson, the land is higher, and no longer a narrow ridge. Torrent-gullies, opening to the harbour as small bays, are separated by tapering spurs which run down nearly to sea-level without change of slope. The points only of the spurs have been truncated by wave-action, and a marked decrease in the height of wave-cut facets can be traced northward on successive spurs. This appears to correspond to the decreasing energy of waves, running along the shore, with

* *Loc. cit.*, p. 539.

increasing distance from the open sea. Before the delta of the Hutt River, at the head of Port Nicholson, is reached, effects of wave-action have shrunk to small dimensions, and the spurs which run down into the flats of the delta are not truncated at all.

It will be gathered from the above description and from fig. 11 that the eastern shore of the harbour presents characters similar to those of any ridge in highly inclined stratified rocks, determined by the resistant nature of the stratum of which it forms the outcrop. It is continuous with the ridge forming the divide east of the Hutt River. This divide runs for some distance parallel with and very close to the Hutt River; hence the tributaries entering the Hutt, or its continuation, Port Nicholson, can be only short, steep-grade torrents. The nearness of the divide to the Hutt at this point is explained by the fact that the ridge is composed of the strong greywacke with few joints, which is the hardest rock in the district. If, on the other hand, the ridge-face were determined by a line of recent faulting, and the ridge itself were composed of rocks of average or varying hardness, it might be expected that some of the streams of the fault-scarp would have worked through and captured the drainage at the back, as the streams of the Wellington fault-scarp have done. This ought all the more to be expected in the case under discussion, since, if it be a case of faulting, the actual scarp has reached a much more mature stage of dissection than the scarp of the Wellington fault.

The question of what actually is the eastern boundary of the Port Nicholson depression must for the present remain open.

There remains the line on the western side from Kelburne through the City of Wellington to the sea on the south. This is the line of one of McKay's faults (No. 3).* A section across this fault or a branch of it may be seen in the cuttings of the Brooklyn tramway, but the section gives no information as to the date of faulting or amount of movement. There is rather indefinite evidence of faulting in the steep scarp along the front of Kelburne and Brooklyn (the line AB in fig. 2). Evidence of faulting is much obscured owing to the fact that the line of fracture appears to have followed the course of a longitudinal mature valley in weak rock, the floor of which was very deeply weathered. The amount of movement appears to have been between 200 ft. and 300 ft. Farther south there is little evidence of a scarp, and the fault was perhaps replaced by a flexure.

Changes in Drainage of the Karori-Khandallah or Long Valley.

This old valley might be called the Karori-Khandallah Valley, from the names of two important settlements in it. For the sake of brevity, it is here called the "Long Valley." Its line is now followed by the Silver Stream, the Kaiwarra and its tributaries, the upper Ngahauranga, and the Porirua. In fig. 2 the line of the old valley is indicated as a double broken line, and farther north by the line of the Manawatu Railway. Starting at the head of the valley and following it northward, we may note the changes that have taken place. At the head of the Silver Stream, which occupies the southern end of the valley, the divide is now 1,000 ft. above the sea, and the old valley appears to have continued still farther southward, the divide now being rapidly pushed northward by the activity of torrents of the south coast. Two miles and a half from its source the Silver Stream turns very sharply

* *Loc. cit.*, p. 1.

to the west, and finds its way to the sea as a tributary of the Karori, having thus a roundabout course eight miles in length. As indicated in fig. 2, the capture of the Silver Stream by the Karori is a double one, two branch ravines of the Karori tributary having successively tapped the course of the Silver Stream. The floor of the old Long Valley here stands about 840 ft. above sea-level. The deepening of the captured stream at the elbow of capture is 400 ft. or 500 ft. Northward from this divide the Kaiwarra, which here occupies the Long Valley, descends somewhat rapidly in a trench incised in an older mature valley-floor. At the upper reservoir (U.R. in fig. 2) it follows entrenched meanders of small radius, and a portion of the old flood-plain on which the meanders originated remains as a bench far above the present stream and at a height of 660 ft. above the sea. At this point a mature dry valley on a level with the old flood-plain bench, evidently the old stream-course, swings off to the north, while the course of the Kaiwarra, flowing north-east, is a young gorge. The sketch, fig. 12, shows the old valley and the young gorge of the Kaiwarra.

Following the old dry valley mentioned above, we find ourselves in the broad mature valley occupied by the settlement of Karori. It has been invaded by the head of the Karori Stream from the south-west, as well

FIG. 12.—CAPTURE OF THE "LONG VALLEY" STREAM BY THE KAIWARRA.
Upper reservoir on the left; young gorge of the Kaiwarra below the upper-reservoir dam on the right.

as by the Kaiwarra from the north-east. The north-eastward continuation of the now broad and mature Long Valley through Ngaio and Khandallah is evident, but between Karori and Ngaio the floor of it has been almost completely gouged out by the numerous young deep-gorged tributaries of the middle Kaiwarra. Overlooking the Kaiwarra there are, however, abundant stream-deposits in Karori, and a bed of gravel on the western slope of the Tinakori hills at a height of 600 ft.

The lower Kaiwarra leaves the Long Valley by a steep-walled gorge, and crosses the scarp of the Wellington fault. The north-eastward continuation of the valley is occupied next by a short obsequent stream, a tributary of the Kaiwarra. Farther on, at Khandallah, it is crossed by a stream which joins the Ngahauranga near its mouth. Still farther to the north-east the valley has been invaded by the Ngahauranga, a stream which, owing its activity to its position on the fault-scarp, has worked back in a profound gorge along a nearly straight course at right angles with the

fault-line until reaching the Long Valley. It has reversed the drainage of the Long Valley for a mile and a half. It follows a winding course, but the tapering shape of the spurs on the concave sides of the meander-curves indicates that the winding character is due, at least in part, to lateral cutting that has accompanied the deepening of the gorge. At one point a narrowed and almost cut-off spur is a conspicuous feature in the Ngahauranga Valley. Plate XXI, fig. 1, is a view looking north-east across this spur and up the valley. The height of the narrowed neck above the stream on the down-stream side is 200 ft., and on the up-stream side 90 ft. Its breadth is about 100 yards, while the distance roundabout by the course of the stream is three-quarters of a mile. Beyond the divide, 500 ft. above sea-level, at the head of the obsequent Ngahauranga, is the head of the Porirua Stream, which, robbed of two-thirds of its ancient length, still occupies the northern end of the Long Valley. Probably this was the outlet at the close of the Tongue Point cycle.

The cause of most of the captures in the Long Valley is, as has already been indicated, the subsidence of the Port Nicholson block, particularly along the line of the Wellington fault, giving a short descent to sea-level. With regard to the Silver Stream, it seems remarkable that its capture had not taken place earlier and in a less roundabout way than the present outlet to the Karori Stream. A reasonable explanation seems to be that in earlier times, when streams followed the Long Valley and the other main longitudinal valleys of the Wellington Peninsula, the peninsula formed part of a land-area extending to the north-west and to the south far beyond its present limits. Reasons have already been given for the writer's belief that the present coast was determined by fractures after the main lines of the present drainage were established.

Type of Topography.

A consideration of the courses of streams and the elongation of ridges of the Wellington district leads to the conclusion that, apart from local complications due to unequal vertical movement, the topography of the south-western end of the North Island mountain-chain is of the Appalachian type—namely, an old, folded range subjected for a sufficient time to denudation to bring about longitudinal drainage by subsequent streams adjusted to structure, not following original synclinal folds, and afterwards elevated sufficiently to allow dissection by revived streams to produce a surface of strong relief. The analogy with the Appalachian Mountains must not be pushed too far. For example, planation in the earliest cycle seems to have been far from complete, and the absence of transverse streams following antecedent courses is especially noticeable. Their unfortunate absence accounts for the difficulty of railway-construction between Wellington and the western coast. In spite, however, of the obvious differences the remarkable similarity of our range to the Appalachians is brought out by a comparison with Lesley's map of Pennsylvanian topography, repeated by de Lapparent,* or with the detailed maps of smaller areas given by Salisbury and Attwood.† It may be noted that the "great Cook Strait river" of Crawford,‡ it if existed, must have been transverse for part of its course; but reasons have been given above for believing that Cook Strait is not a drowned river-valley.

* "Leçons de Géographie physique," 1907, p. 613.
† U.S. Geol. Survey, Prof. Paper 60, 1908, especially pl. 5 and 56.
‡ Trans. N.Z. Inst., vol. 7, 1875, p. 448.

Summary.

The following conclusions have been reached :—

(1.) The south-western extremity of the North Island of New Zealand is probably a horst isolated by subsidence of land blocks on the west and on the south, and possibly on the east also.

(2.) The drainage-system has been developed by normal processes during a long period of elevation punctuated by pauses, the amount of elevation being at least 800 ft., and probably more.

(3.) The nature of the longitudinal drainage suggests that adjustment to structure was established in an earlier erosion period.

(4.) A prominent feature, Port Nicholson, has been produced by the subsidence of a block along lines which, with one notable exception, have not been clearly recognized.

(5.) This exception is the line of the Wellington fault, along which fault-scarp topography is well developed.

(6.) Recent changes of drainage have had the effect of destroying, rather than completing, previous adjustment to structure.

(7.) This is attributable to the activity of transverse streams on and near to fault-scarps.

Art. XXVIII.—*The Composition of some New Zealand Foodstuffs.*

By John Malcolm, M.D., Physiology Department, University of Otago.

[*Read before the Otago Institute, 5th December, 1911.*]

I. Oysters from Stewart Island.

Most of the oysters consumed in New Zealand come from the Bluff and Stewart Island. Owing to their comparatively large size, their pleasant flavour, and moderate price they form a much-prized addition to the dietary of all classes. So far as the writer knows, no analyses of these oysters have been published hitherto.

The samples examined were procured from a fishmonger in the usual way, and were then probably not more than three days out of the sea. The analysis was begun forthwith, care being taken in opening the oysters not to allow particles of the shell to mix with the contents. The amount of sea-water and other fluid obtained on opening and draining the oysters amounted to about 3 c.c. each, a quantity, however, which depends on the time elapsing between opening and draining. As the animal dies it undergoes rigor mortis, or some analogous change, with the result that more fluid can be drained off; if heated even slightly the amount is still more increased. In the samples analysed the opened oysters were immediately drained under light pressure in a cheese-cloth, then minced, dried, ground in a coffee-mill, and preserved in powder form.

Methods.

Glycogen was estimated in the fresh material by Pflüger's method—*i.e.*, the weighed sample was heated with strong KOH on the boiling-

water bath for three hours; the glycogen was then precipitated with alcohol, washed, and converted into glucose, which was estimated by Fehling's method.

Fat was estimated by Rosenberg's method — *i.e.*, extraction of the dried material with boiling absolute alcohol and chloroform alternately, with subsequent ether extraction of the material so obtained.

Protein was calculated from the amount of nitrogen on the assumption that the nitrogen formed 16 per cent. of the molecule. It was recognized, of course, that all the nitrogen present was not in the form of protein—in fact, oysters owe much of their value in dietetics to the presence of nitrogenous extractives; on the other hand, they contain much nucleo-protein, or a similar body rich in phosphorus, in which the nitrogen must be under 16 per cent.

Ash or mineral matter was estimated by incineration, aided by extraction with hot distilled water and subsequent evaporation of the extract.

The results are given in Tables I and II.

Table I.—Composition of Stewart Island Oysters.

	I. May 24.	II. May 25.	III. May 31.	IV. Oct. 31.
Edible matter per oyster	12 g.	9 g.	11·5 g.	8·6 g.
Dried solids per oyster	...	2·5 g.	2·24 g.	1·8 g.
Water, per cent.	...	75·8	75·2	78·8
Solids, per cent. (by difference) ...	...	24·2	24·8	21·2
Glycogen, per cent.	3·36	...	3·74	0·5
Protein, per cent. (N × 6·25) ...	...	12·20	13·72	12·72
Fat, per cent.	...	3·66	3·47	1·83
Salts, per cent.	...	2·34	2·71	2·43
Percentage unaccounted-for (assuming that II had same glycogen per cent. as I)	...	2·37	1·16	3·72

In the above table it may be observed that samples I, II, and III were obtained early in the season, sample IV at the end, and on comparing these it is evident that a marked deterioration of the oyster occurs by the end of the season: it becomes more watery, glycogen drops to one-seventh of its initial value, the fat diminishes to nearly half, and the extractives are relatively increased. It would be interesting scientifically, and would throw a valuable light on what ought to be the limits of the oyster season in New Zealand, if analyses were made at regular and frequent intervals throughout the year.

Table II.—Comparison of Percentage Composition of Dried Solids.

	II.	III.	IV.	American Oysters.*
Protein ...	50·51	55·56	60·00	52·13
Glycogen ...	15·00	15·00	2·35	28·20
Fat ...	15·14	14·01	8·64	11·96
Salts ...	9·67	10·94	11·47	16·23

From Table II it will be seen that at their best the New Zealand oysters contain much less glycogen and relatively more fat than the average American oyster.

* Calculated from an analysis by Langworthy quoted in Hutchison's "Food and Dietetics."

Qualitative Examination.

Protein.—As already mentioned, oysters contain a large amount of nucleo-protein or similar body rich in phosphorus. Besides this a saline extract of oysters contains a protein which coagulates about 75° C.

Fat and Pigment.—To the naked eye the ethereal extract of dried oysters appears brown, as is generally the case with fats dried at high temperatures. On spectroscopic examination this ethereal solution shows a distinct absorption band near the red end of the spectrum—apparently nearer that end than the characteristic band of methaemoglobin; on dilution the band approaches and fuses with the infra-red part of the spectrum. It is probably a lipochrome, as it is absent from watery extracts, and occurs only in extracts made by solvents of fat (ether, chloroform, acetone, alcohol, amyl alcohol, &c.). It was found in all the samples examined.

II. Frostfish (*Lepidopus caudatus*).

This peculiar-looking fish, known in other parts of the English-speaking world as "scabbard-fish," is found in the Mediterranean and warmer parts of the Atlantic as well as around the Tasmanian and New Zealand coasts. It derives its popular name from the fact that it is thrown up by the sea in frosty weather, and is found dead or dying on the beach. According to one view, it comes ashore voluntarily, as if bent on self-immolation; it has seldom, if ever, been caught alive, and is generally believed to be a deep-water fish. In shape it is long and ribbon-like, and has a bright scaleless skin. Unlike many New Zealand food fishes, it has a distinctive flavour, and partly from this and partly no doubt, from its comparative rarity it is regarded as a delicacy, and sells at 1s. 6d. to 3s. per pound. For the purposes of sale and for cooking it is cut into slices across its long axis; all such cutlets include the vertebral column, and some also include the abdominal cavity. There is a considerable amount of waste matter in the cutlets; thus in an ordinary slice as bought only 85 grm. out of a total of 134 grm. consisted of edible flesh. The residue (36·5 per cent.) consisted of bone, skin, and tough intermuscular septa, although the latter would probably form gelatine during the process of cooking, and should not be considered altogether as waste.

Fat.—The flesh is obviously fatty, and an oily scum forms on the water in which it is boiled; but the fat is unequally distributed, there being much more in the tissues immediately surrounding the abdominal cavity than in the muscles of the sides. In the first sample examined the fat of the dorsal portion or sides of the fish amounted to 4·55 per cent., and that of the ventral to 16·77 per cent. In the second sample there was 7·36 per cent. fat in the sides, and 20 per cent. in the ventral portion. From the culinary point of view, therefore, the frostfish should be reckoned as a fatty fish somewhat akin to turbot. The fat extracted by ether is a yellow-coloured oil, half-fluid at room-temperature, and possessing a smell which recalls that of cod-liver oil. It contains 1 per cent. of nitrogen.

Protein.—Owing to the presence of a considerable amount of non-protein nitrogenous substance, it is not permissible in this case to use the total nitrogen as the basis for calculating the percentage of protein. The following procedure was therefore followed: The residue, after extraction of the fat, &c., by chloroform and alcohol, was weighed and sampled for nitrogen-estimation—thus 10·967 grm. partly dried "sides"

of fish, representing 37·45 grm. fresh material, was extracted with chloroform and with alcohol; the residue weighed 8·412 grm.; the nitrogen percentage of this was 12·56, which equals 2·807 per cent. of protein-nitrogen in the moist fish, or 17·54 per cent. protein. The total nitrogen of the moist frostfish was found to be 3·6 per cent. Deducting the protein-nitrogen (2·8 per cent.) we obtain 0·8 per cent. of nitrogen belonging to non-protein material. As already stated, the ether-soluble "fat" contains 1 per cent., but even after deducting this value (0·08) we have 0·72 per cent. nitrogen to account for, and, as will be mentioned later, this nitrogen was partly present in a special crystalline substance soluble in alcohol.

Glycogen could not be detected in the samples of frostfish examined; thus 30 grm. was treated by Pflüger's method without positive result.

The main points brought out by the analysis are shown in the following table:—

Table III.—Composition of Frostfish. (Flesh of "sides" or dorsal portion only.)

	Sample 1.	Sample 2.
Water, per cent.	76·8	73·5
Solids, per cent.	23·2	26·5
Fat, per cent.	4·55	7·36
Total nitrogen, per cent. ...	2·82	3·6
Protein, per cent.	Under 17·6	17·54
Glycogen	...	Nil.
Alcoholic extract, per cent. ...	...	0·8
Ash, per cent.	1·15	1·28

The data obtained from analysis of the ventral part of the fish are as follows:—

Sample 1.—Fat, 16·77 per cent.; substances soluble in boiling water (gelatine and salts), 3·7 per cent.; substances insoluble in boiling water (coagulated proteins, &c.), 2·73 per cent. The water percentage was not estimated. These figures are calculated on the assumption that it was the same as in the other parts of the fish.

Sample 2.—24·8 grm. ventral portion of frostfish gave 4·9584 grm. ether-soluble fat = 20 per cent.

Crystalline Substance.—On boiling fresh minced frostfish with 96 per cent. alcohol, and allowing the extract to cool, a fine white crystalline deposit formed. Under the microscope two types of crystals appeared to be present; the more numerous were balls of fine, pointed needles slightly bent or twisted so that they resembled puff-balls, the others were much smaller rounded clumps of indeterminate crystalline matter. At first sight they might be mistaken for leucin and tyrosin. When filtered and allowed to dry in the air the deposit formed a white powder, easily soluble in water. It gave no biuret or Millon's reaction, and did not reduce Fehling's solution. Ammonia caused a slight precipitate. When directly tested the powder gave distinct evidence of carbon, nitrogen, and phosphorus.

While frostfish is undoubtedly of high nutritive value, and an excellent article of diet, the conditions under which the fish is obtained, its doubtful degree of freshness, its high percentage of fat which from its oily nature is apt to become rancid, the presence of a special alcohol-soluble substance at present of unknown nature, all tend to make one careful in advising its use for invalids. Parasitic worms—small, round,

and coiled like a watch-spring—occur fairly often; they are probably quite harmless.

III. Kumara, or Sweet Potato.

The kumara, or Maori sweet potato, is cultivated to a considerable extent in the North Island of New Zealand. It seems to be the same as the sweet potato of America and the Pacific islands generally, but some slight differences in the composition were found, and these deserve to be put on record. No complete detailed analysis was made.

Carbohydrate.—Starch, in the form of granules which present the usual appearance of batata-starch, constitutes the most important of the solids. On hydrolysis it yields a dextro-rotatory reducing-sugar.

Dextrin.—Fresh kumaras were extracted first with absolute alcohol to remove sugar and other substances, then with cold water after driving off the traces of alcohol. On adding alcohol this yielded a flocculent precipitate when the alcohol present amounted to 60 per cent. This precipitate was separated out and dissolved in water. It gave reactions corresponding to those of a dextrin—viz., no reduction till after hydrolysis—and with iodine a dull-violet colour.

Cane Sugar (?).—An alcoholic extract of kumaras contains all the reducing-sugar present. If a watery solution of these sugars be hydrolysed the reducing-power is markedly increased. Thus in two separate samples the increase in reducing-power on hydrolysis indicated that 63·6 per cent. of the sugar was in this form.

Monosaccharide (?).—A fresh watery extract of kumaras always shows reduction. If left lying in the laboratory for a few weeks the kumaras tend to grow mouldy, probably due to the sugars present, and the amount of sugar of both kinds shows a slight increase (0·11 per cent. in seventeen days in one case). In the process of drying minced kumaras to produce a powder for analysis there seems to be an increase in the amount of sugar formed. If the drying is done on a water bath where steam can reach the material, it forms gum-like masses, due to dextrin-formation, so that for analytical purposes drying is best done in an oven.

Protein.—The amount of protein is comparatively small, being at most not more than 3 per cent., as indicated by the total nitrogen. An estimation of the nitrogen in the flocculent precipitate obtained on boiling a cold-water extract of kumaras indicated less than 1 per cent. protein.

Fat.—The ether-soluble substances form a very small percentage of the solids (0·27 per cent.). They resemble resins or oleo-resins more than true fats, and it seems to be to these that kumaras owe their flavour.

Ash.—The ash contains calcium, iron, magnesium, and phosphoric anhydride.

The following table gives the main points examined:—

Table IV.—Composition of Kumara.

	Sample 1.	Sample 2.	Sample 3.	American.
Water, per cent.	68·44	67·7	77·35	69·0
Solids (by difference), per cent.	31·56	32·3	22·65	31·0
Starch, per cent.	24·84	...	3·78	26·2
Cane sugar, per cent.... ...		...	...	
Monosaccharide, per cent. ...	2·7	.	2·17	
Protein, per cent.	1·71	2·84	1·73	1·3
Fat, per cent.	0·27	...	. .	0·6
Ash, per cent.	1·05	. .	..	0·8

Art. XXIX.—*Montan Wax.*

By Theodore Rigg, M.Sc. (Jacob Joseph Scholar in Victoria College).

Communicated by Professor Easterfield.

[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

INTRODUCTION.

Montan wax is a hard yellowish material which, on account of its high melting-point, is used for raising the melting-point of stearine candles, and, on account of its low price, has also found some use as an adulterant of beeswax. The wax was first manufactured from the brown coal of Saxony and Thuringia, and more recently has been prepared from Irish lignites.

In the manufacture of montan wax, pyropissite is either extracted with light petroleum and the soluble bitumen, obtained from the extract, then distilled in superheated steam, the distillation being repeated until a nearly colourless product is obtained, or the brown coal is itself distilled with superheated steam.

The method of manufacture was first patented by E. von Boyen (German patent 101373, 1st July, 1897). In the original patent E. von Boyen* described the wax as consisting of two well-characterized substances—an acid and an unsaturated hydrocarbon. C. Hell† assigned the formula $C_{29}H_{58}O_2$ to the above-mentioned acid, now called "montanic acid."

E. von Boyen‡ adopted the formula $C_{29}H_{58}O_2$ for the acid, but now stated that the other constituent is an alcohol melting at 60°, which is readily attacked by sulphuric and nitric acids. He regarded the original bitumen as an ester of montanic acid which is decomposed during distillation.

K. Eisenreich§ purified montanic acid by fractional precipitation with magnesium acetate. He adopted the same formula for the acid as von Boyen and Hell. He noted that the last portions of the acid to be precipitated melted several degrees lower than the earlier fractions, but no attempts were made to obtain acids of lower molecular weight from these fractions.

To the non-acid constituent of the wax, melting at 63·5°, he assigned the formula $C_{42}H_{86}O$, and supported the formula by an ebullioscopic molecular-weight determination, but could not find any evidence that the substance was an alcohol.‖

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* Chem. Central Blatt, 1899, vol. 1, p. 864.

† Zeit. f. Angew. Chem., 1900, p. 556.

‡ Chem. Central Blatt, 1901, vol. 2, p. 1285.

§ Journ. Soc. Chem. Ind., 1909, p. 991.

‖ Such a formula, $C_nH_{2n+2}O$, can only represent an alcohol or an ether derived from a higher alcohol; but the low melting-point of the substance (63·5°) makes it extremely improbable that the compound is anything else than a hydrocarbon.

Ryan and Dillon* gave the formula for montanic acid as $C_{28}H_{56}O_2$. The non-saponifiable portion they found to melt at 58–59°, and the analysis gave 2·5 per cent. of oxygen, which agrees approximately with the formula $C_{42}H_{86}O$ of Eisenreich. They also stated that no primary or secondary alcoholic group is present in the substance.

The work of previous observers may therefore be summed up as follows: (*a.*) Three investigators have assigned to montanic acid the formula $C_{29}H_{58}O_2$, while one investigator has assigned the formula $C_{28}H_{56}O_2$ to the same acid; (*b.*) von Boyen first stated that the non-acid constituent was an unsaturated hydrocarbon, afterwards that it was an alcohol. Eisenreich and also Ryan and Dillon state that the non-acid constituent is not alcoholic in nature, but regard it as an oxygenated compound.

In the present paper it is shown that: (1) the "montanic acid" occurring in the wax is in reality a mixture of three acids—cerotic ($C_{26}H_{52}O_2$), montanic ($C_{28}H_{56}O_2$), and melissic ($C_{30}H_{60}O_2$) acids; (2) the non-saponifiable portion is an olefinic hydrocarbon, probably $C_{28}H_{56}$ or $C_{26}H_{52}$, both of which, being olefines, would have, of course, the same percentage composition.

Cerotic and melissic acids were described by Brodie† as constituents of beeswax, but have not hitherto been found in any mineral substance. The separation of these acids was tedious, involving a series of over forty fractional precipitations by magnesium acetate, whereby the cerotic and melissic acids were obtained in a state of purity.

Montanic acid, the acid of intermediate molecular weight, was isolated by conversion of the crude acid into its ethyl salt, and subsequent distillation under reduced pressure. Some fifteen fractionations were needed before the substance could be considered pure.

After purification, the cerotic and montanic acids both crystallized in pearly scales. Hitherto cerotic and montanic acids have been described as crystallizing in needles; and the crude acids certainly do so, but the pure acids crystallize in scales, and in so doing resemble all the lower members of the higher fatty acids which have been obtained in a state of purity.

There can be little doubt that cerotic, montanic, and melissic acids belong to the homologous series of the higher fatty acids, and that these acids are all normal fatty acids. A comparison of the physical properties of a number of their derivatives supports this (Tables I–III, p. 285). In the case of montanic acid it has been possible to show that the substance is undoubtedly normal heptacosane carboxylic acid.

The occurrence of montan wax as the principal product of steam distillation of bituminous coal is of great interest. Krämer and Spilker‡ have shown that fats and waxes, if distilled under pressure, yield mixtures of hydrocarbons not unlike many natural petroleums, and they have suggested that some petroleums at least owe their origin to the decomposition of wax derived from algae.

At first it appears difficult to imagine such supplies of wax in nature as, by decomposition, would give rise to the immense quantities of oil present in the large oilfields. Brown coal is, however, even more widely distributed

* Sci. Proc. Roy. Dub. Soc., vol. 12, p. 20, 1909.
† Phil. Trans. Roy. Soc., 1848.
‡ Berichte, vol. 32, 1899, and vol. 35, 1902.

than petroleum, so that the suggestion of these authors gains in probability, in that it is known that large quantities of wax, almost certainly derived from micro-organisms, are present in this lignite.

Krämer and Spilker's hypothesis would appear, in this light, much more probable than that of Mendeleef, Moissan, and others, who suggest that the natural petroleums are due to the action of water upon metallic carbides, substances which have never been found in nature in large quantity.

If we assume with von Boyen that the bitumen derived from pyropissite is an ester of montanic acid, then the fact that the inert constituent of the wax derived from the bitumen is an olefinic hydrocarbon, probably $C_{28}H_{56}$, suggests that the reaction during steam distillation of the wax is represented by the equation

$$C_{27}H_{55}CO_2C_{28}H_{57} = C_{27}H_{55}CO_2H + C_{28}H_{56}$$
Montanyl montanate = Montanic acid Montanene.*

just as during the distillation of Chinese wax we have—

$$C_{25}H_{51}CO_2C_{26}H_{53} = C_{25}H_{51}CO_2H + C_{26}H_{52}$$
Ceryl cerotate = Cerotic acid Cerotene.

It is to be hoped that the time is not far distant when a systematic examination of the brown coals and oil-shales of New Zealand will be made, with the object of elucidating the chemical nature of their constituents. It is a regrettable and remarkable fact that, notwithstanding the enormous annual consumption of coal in all countries of the world, we are still practically in ignorance as to the chemical nature of this fuel.

EXPERIMENTAL.

Part I.—The Composition of Montan Wax.

A. THE ACID CONSTITUENTS.

The following table gives a comparison of the physical constants of the montan wax† used in this research with those of the waxes used by Eisenreich‡ and Ryan and Dillon.§

	Wax used by Author.	Eisenreich's Wax.	Ryan and Dillon's Wax.
Melting-point ..	78°	77°	76°
Acid value	86·2	93·02	73·3
Saponification value ..	88·4	94·56	73·9
Percentage of montanic acid (if M.W. = 424)	65·0	72·66	53·0

It will be seen that the three samples of wax melt within 2° of one another, and that the wax used in this research had an acid and saponification value intermediate between those of the other investigators. Slight differences in the rate of distillation of the original material would readily account for these differences in the properties of the wax.

* The fact that the proportion of hydrocarbon in commercial montan wax is much less than that of the free acids is not surprising, for the physical properties of the hydrocarbon are such as to lead to loss during the commercial process of recrystallization from benzene.

† This montan wax was obtained from Schliemann and Co., Hamburg and London.

‡ Journ. Soc. Chem. Ind., 1909, p. 991.

§ Sci. Proc. Roy. Dub. Soc., vol. 12, 1909.

Crude Montanic Acid.

Crude montanic acid was extracted from montan wax by the following process: 500 grams of montan wax were digested five times with hot alcohol, about 3 litres for each extraction. This hot alcoholic solution, containing practically the whole of the free acids, was siphoned off, neutralized with ammonia, and the acids were then precipitated as calcium salts by means of alcoholic calcium-chloride solution. The calcium salts were then filtered off by means of a hot funnel.

The crude calcium salts thus obtained were dried on the water bath, and then pulverized and boiled out six times with alcohol. Motor spirit, although a very good solvent of unsaponifiable matter, could not be employed for the purification of the calcium salts, by reason of the almost unfiltrable paste produced in this case.

The calcium salts were now decomposed by glacial acetic acid, and the crude acid thus obtained melted at 81·5°. Crystallization from motor spirit raised the melting-point to 82·5°, but further crystallization from alcohol, motor spirit, and acetic acid did not further raise the melting-point. The acid crystallized from acetic acid in granules.

The titration of the acid thus obtained, although the greatest care was taken in the standardization of the decinormal solutions employed, gave a molecular weight of 432—*i.e.*, almost the mean of the molecular weights required for the formulae $C_{29}H_{58}O_2$ and $C_{28}H_{56}O_2$.

It thus appeared that either the montanic acid contained some inert compounds such as hydrocarbons or ketones, or that it was admixed with a higher acid. To test the first of these suppositions the acid was purified by potash-lime saponification with an excess of lime, and then extraction with hot motor spirit in which high-molecular-weight hydrocarbons and ketones are readily soluble. The molecular weight of the purified acid, however, remained unchanged (430).

That the acid, although its melting-point was unaltered by further crystallization, was not a single compound was demonstrated by submitting 10 grams of the acid to fractional precipitation with magnesium acetate, for the regenerated acids from the different fractions had the following melting-points:—

		Melting-point.
Fraction I (weight $\frac{1}{10}$ of original acid taken)	..	85·5°
,, II ,, $\frac{3}{10}$,,	..	83–84°
,, III ,, $\frac{4}{10}$,,	..	81–82°
,, IV ,, $\frac{1}{10}$,,	..	74·5°

Fractional precipitation was therefore undertaken on a large scale. 50 grams of crude montanic acid were dissolved in 800 c.c. of alcohol, the solution rendered alkaline with ammonia, and then precipitated with 20 c.c. of a solution of magnesium acetate (equivalent to 10 grams montanic acid). Four fractions were thus precipitated, and a fifth fraction was obtained from the alcoholic filtrate on cooling. The regenerated acids from these fractions had the following melting-points:—

	Melting-point.
Fraction 1	83·5–84°
,, 2	83–84°
,, 3	82–83°
,, 4	81–82°
,, 5	74–76°

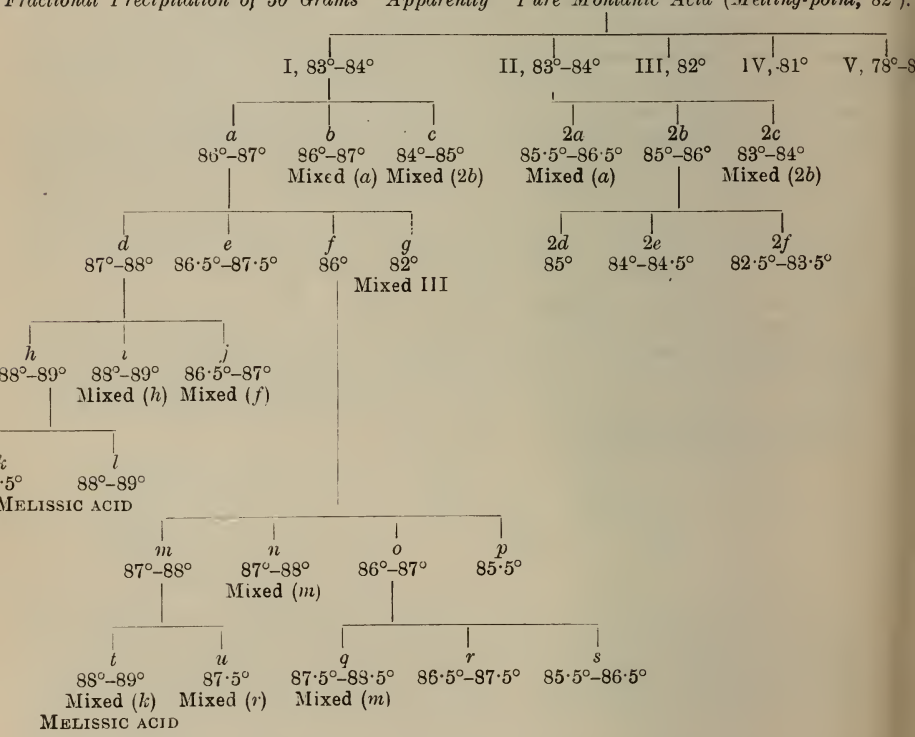
This practically agrees with Eisenreich's experience. He obtained the first four fractions melting at 83°. It seems strange that he did not proceed with further fractional precipitation.

Fractions 1 and 2 were each fractionally precipitated again, and it was found that the regenerated acids from the first two precipitates had risen 3° in melting-point.

Fractions which melted within 1° were mixed before the next precipitation was proceeded with. After four consecutive precipitations of the highest melting fraction in each case, there resulted an acid melting at 88·5°. This fraction was not altered in melting-point by a series of further fractional precipitations, and must be regarded as pure melissic acid, which, according to Brodie* and to Schwalb,† melts at 88–89°. It is, however, to be noted that the melissic acid from the oxidation of canaüba wax is stated by Maskelyne‡ to melt at 91°.

The following is a scheme of precipitations employed in the isolation of melissic acid. The melting-points given are those of the regenerated acids:—

Fractional Precipitation of 50 Grams "Apparently" Pure Montanic Acid (Melting-point, 82°).



Repeated fractional precipitation failed to yield an acid melting at about 83° which could be considered pure, but from fraction 5 precipitation yielded lower fractions, which when repeatedly crystallized melted at

* Phil. Trans. Roy. Soc., 1848.
† Annalen, 235, p. 135.
‡ Journ. Chem. Soc., 1869, vol. 22, p. 87.

78–78·5°, and were absolutely identical with the cerotic acid of beeswax. This identity was proved as follows :—

(*a*.) Both acids had the same melting-point, and a mixture of the two acids melted within 0·5° of the original acid.

(*b*.) The ketone prepared from each, by means of the catalytic action of metallic iron, melted at 92·5–93°.

(*c*.) The ethyl esters of each acid had the same boiling-point, 285°, at 14 mm.

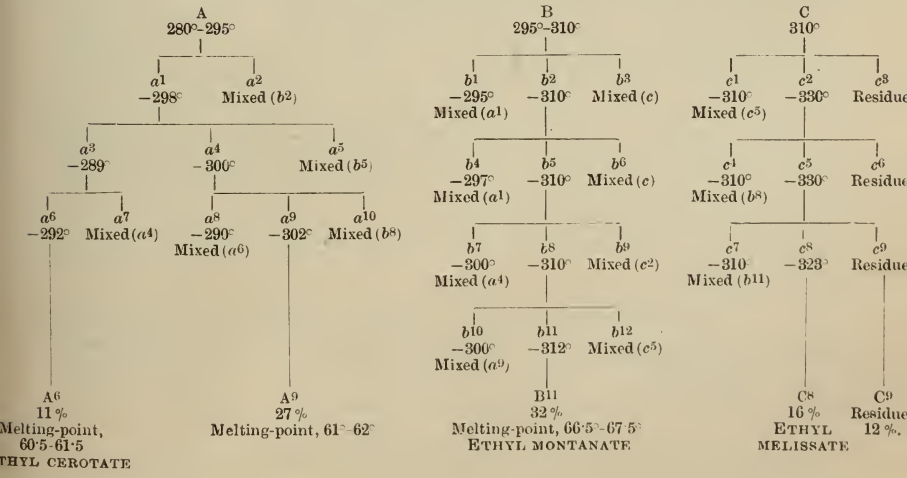
(*d*.) Both acids crystallized in pearly scales.

Preparation of Pure Montanic Acid.

Although the method of fractional precipitation did not yield montanic acid in a state of purity, yet by fractional distillation of the ethyl ester of the crude acid under diminished pressure purity was at last attained. 100 grams of crude montanic acid were dissolved in 2,300 c.c. of 95-per-cent. alcohol, to which had been added 60 c.c. strong sulphuric acid. The whole was kept hot on the water bath for forty-four hours. It was found that equilibrium was attained within thirty hours, but if 95-per-cent. alcohol is used there still remains 6 per cent. of acid unconverted to ester. The crude ester was therefore reheated with absolute alcohol and a little sulphuric acid in order to complete the esterification, and now gave, after removal of mineral acid, only the slightest trace of free organic acid.

The ester obtained by the above process was carefully washed free from sulphuric acid, then dried in a vacuum over sulphuric acid, and distilled under reduced pressure. The apparatus employed for this purpose was novel, in that the neck of the distilling-flask was electrically heated, and in that a special type of fractionator was used. Three fractions were always collected from each distillation. The following diagram shows at a glance the method of procedure and the number of distillations performed :—

Crude Ethyl Montanate (Melting-point, 66°). All distillations done under a pressure of 14–16 mm.



The following table is a comparison of the physical constants of the five final fractions obtained by repeated distillation :—

No.	Boiling-point.	Melting-point, Ester.	Melting-point, Acid.	Per Cent. Weight of Fraction.	Molecular Weight.	Apparent Formula.
A6	–292°/15 mm.	60·5–61·5°	78·7–79·7°	11	385	$C_{25}H_{50}O_2$
A9	–302°/15 mm.	61–62°	81–82°	27	413	$C_{27}H_{54}O_2$
B11	–312°/15 mm.	66·5–67·5°	83°	32	427	$C_{28}H_{56}O_2$
C8	–323°/15 mm.	..	..	16	..	..
C9	Residues ..	..	..	12	..	..

Fractions C8 and C9 were obviously impure, being mixtures of montanic acid and melissic acid, together with some ketone. The free acid derived from these two fractions did not crystallize in plates, and gave titration values much above that required for montanic acid. From the residues, after saponification, a single fractional precipitation gave a regenerated acid, melting at 88·5°, which corresponds with the melting-point of melissic acid.

The acid obtained from the saponification of B11 is to be regarded as pure montanic acid,* for further fractional distillation of the ester did not alter the melting-point of the ester or of the acid obtained from the ester, nor did it affect the titration value of the acid thus obtained within the limits of experimental error. Thus, acid from B11 : 1·0785 grams reqd.

$$25{\cdot}60 \text{ c.c. } \frac{N}{10} \text{ KOH} = \text{M.W.} = 421.$$

Acid from B11 twice redistilled : 1·845 grams reqd.

$$43{\cdot}70 \text{ c.c. } \frac{N}{10} \text{ KOH} = \text{M.W.} = 427.$$

The titration values approach very closely to that required for a formula $C_{28}H_{56}O_2$, thus placing montanic acid among the even members of the higher fatty acid series. The montanic acid purified by this process crystallized in plates, and was readily soluble in hot ethyl acetate or motor spirit, and fairly soluble in hot alcohol and acetic acid.

In concluding this section on the acid constituents the writer wishes to summarize the following results :—

(*a.*) Crude montanic acid is a mixture of cerotic, montanic, and melissic acids.

(*b.*) Pure montanic acid crystallizes in plates, melts at 83°, and has a molecular weight corresponding to the formula $C_{28}H_{56}O_2$. (Previous experimenters have described it as crystallizing in needles, which is correct so long as the substance is impure.)

(*c.*) Cerotic acid has also been obtained for the first time in nacreous crystalline plates.

B. THE NON-ACID CONSTITUENTS OF MONTAN WAX.

The alcoholic solution of the crude montan wax from which the acids had been precipitated by calcium chloride contained an almost neutral substance, which was recovered by evaporation of the alcoholic mother

* The acid crystallized in pearly scales, which also is an indication of purity.

liquor. To remove the last traces of acid the substance was melted and stirred into powdered quicklime, which was then slaked by means of a solution of potash. The porous mass thus obtained was extracted with hot motor spirit which on evaporation deposited a crystalline substance which after repeated crystallization melted at 59–60° and was unchanged by further crystallization.

On analysis, this substance gave the following values: 0·1492 grams gave 0·4713 grams CO_2 and 0·1882 grams H_2O.

Calc. for C_nH_{2n}.	Calc. for $C_{27}H_{56}$.	Found.
C = 85·71	C = 85·26	C = 86·14
H = 14·29	H = 14·74	H = 14·01

The analysis shows that the substance is probably an olefinic hydrocarbon. This was confirmed by its behaviour with bromine water, which was rapidly decolourized when warmed with it. A rough determination of the bromine absorbed was as follows: 0·25 grams hydrocarbon absorbed 0·073 grams bromine.

Calc. for $C_{28}H_{56}Br_2$.	Found.
Br = 29·0 per cent.	Br = 22·6 per cent.

Note.—Bromination was probably not complete, the reaction being only allowed to proceed for about three hours.

The molecular weight of the hydrocarbon as determined by the ebullioscopic method pointed to a hydrocarbon of molecular weight 380.

0·64 grams hydrocarbon raised the boiling-point of 8·5 c.c. of anhydrous freshly distilled benzene 0·65°.

Molecular weight = 380. Calc. for $C_{28}H_{56}$ = 392.

The melting-point (59–60°), the analysis, and the molecular-weight determination all point to a hydrocarbon of the formula $C_{27}H_{54}$ or $C_{28}H_{56}$, but it is only by the preparation and analysis of the carefully purified dibrom addition product that we shall ascertain whether the substance contains 26, 27, or 28 atoms of carbon.

Part II.—The Acids of Montan Wax, and some Compounds derived from them.

Since the ultimate aim of this research is to show the connection which exists between cerotic, montanic, and melissic acids, it follows that the physical constants of these acids, their melting-points, their molecular weights, and the properties and physical constants of their compounds should be accurately determined.

The accurate correlation of such data affords no small interest to the chemist, as has been pointed out by Krafft,* Franchimont,† and more recently by P. W. Robertson ("The Melting-points of the Anilides, P. Toluidides, and Naphthalides of the Normal Fatty Acids").‡ Furthermore, this series of fatty acids and their derivatives presents a group unsurpassed in the whole of organic chemistry for illustrating the principle of homology, and therefore it is desirable that the physical constants of

* Berichte, vol. 15, 1719.
† Rec. Pays., vol. 16, p. 126, 1897.
‡ Journ. Chem. Soc., 1908, p. 1033.

all the members of the series from the highest to the lowest should be accurately determined and correlated. Moreover, it is desirable that the proof of the constitution of the higher members of the series should be demonstrated with as absolute rigidity as has been the case with the lower acids from acetic to arachidic.

A. CEROTIC ACID AND ITS DERIVATIVES.

Since cerotic acid may be obtained from montan wax only after a very tedious and laborious process, and since the cerotic acid of beeswax has been shown to be identical with that prepared from montan wax, beeswax was therefore used for the preparation of cerotic acid in large quantity.

The beeswax employed for the isolation of cerotic acid was New Zealand unbleached wax, which was obtained from a business firm dealing in large quantities of the natural product, and was guaranteed by them to be pure unadulterated New Zealand beeswax.

The beeswax was examined by Hübl's method, which consists in determinations—(1) the free-acid value, (2) the saponification value, and the determination of the ratio of these two values.

The results are given in milligrams of caustic potash for 1 gram of beeswax. In each determination a blank experiment, using exactly the same quantities of alkali and alcohol, was performed simultaneously with that on the beeswax.

The following are the results of analysis :—

Sample.	Melting-point.	Free-acid Value.	Ester Value.	Saponification Value.	Ratio.
I ..	63°	18·62	72·34	90·96	3·88
II ..	63°	18·62	73·41	92·03	3·94

Lewkowitsch gives numerous estimations of European beeswax. In unbleached wax, he points out the following variations for normal beeswax :—

Melting-point.	Acid Value.	Ester Value.	Saponification Value.	Ratio.
63–64°	19–21	72–74	91–95	3·5–3·78

These figures indicate that the beeswax used had rather a low saponification value, thus inferring the existence of much cerotin in the beeswax. This supposition was strengthened by the fact that on potash-lime fusion* of beeswax, and subsequent isolation and crystallization of the acids produced, a product was obtained melting near the temperature required for cerotic acid.

Cerotic acid was prepared from this beeswax by Brodie's method—namely, extracting quantities of beeswax with successive volumes of ethyl alcohol until the free-acid value for 20 c.c. of the last extraction had been reduced to 2·90 c.c. $\frac{N}{10}$ KOH. Four extractions were necessary to do this.

* According to Gmelin, myricin contains varying quantities of cerotin and real myricin.

The free acid was precipitated by adding alcoholic lead acetate to the boiling solution. The insoluble lead salts were filtered off, and then boiled out repeatedly with alcohol to remove impurities.

The purified lead salts were then decomposed by glacial acetic acid, and the free acid, after washing with water, was extracted with boiling methyl alcohol in which, according to Marie,* melissic acid is insoluble. The solution thus obtained was filtered while hot, and the cerotic acid, which separated on cooling, was then found to melt at 75·5°.

The acid was purified by recrystallization from ethyl alcohol, acetic acid, and motor spirit. An acid was thus obtained melting† at 77·5° (Brodie gives 78° for cerotic acid).

Attempts to improve the process of obtaining cerotic acid by complete saponification of the beeswax with alcoholic potash, followed by the precipitation of the acids with alcoholic calcium-chloride, thus retaining the non-acid substances in solution, were fruitless. It was found that the calcium salts in presence of a saturated solution of high-molecular-weight alcohols were easily soluble, and that the precipitated calcium salts always contained a considerable quantity of organic impurities. Attempts with the lead salts, using the same method, were also unsuccessful.

Cerotic acid has hitherto been stated to crystallize in microscopic needles.‡ Although this is the case when prepared by Brodie's method, yet a careful fractionation of the ester of the acid obtained by the above method gives on hydrolysis a pure acid which crystallizes in pearly plates from acetic acid.

A titration of the cerotic acid purified by fractionation of the ester gave a molecular weight of 392·7, corresponding to the formula§ $C_{26}H_{52}O_2$, thus confirming the formula of Lewkowitsch|| and Henriques.¶

Derivatives of Cerotic Acid.

Cerotanilide.—This compound has not previously been prepared. It was obtained by heating cerotic acid with twice the theoretical quantity of aniline in a sealed tube to a temperature 150° to 170° for four hours. At the expiration of this period the mixture had formed a homogeneous dark soft solid. This was then washed with dilute acetic acid, in order to remove as much free aniline as possible. The anilide thus obtained was then dissolved in alcohol, the solution rendered alkaline with ammonia, and the unchanged cerotic acid precipitated by alcoholic calcium chloride. The filtrate from the insoluble calcium salts deposited the anilide on cooling. It was purified by crystallization from alcohol, acetic acid, and motor spirit.

The anilide thus obtained melted at 98·5° C., and the melting-point was unchanged by further crystallization.

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* Journ. Chem. Soc., 1895, abs. I, 81.

† The melting-point of the purest cerotic acid obtained by the author was 78°. This was obtained by the conversion of the above acid into ester, and then by distillation under reduced pressure.

‡ Beilstein, vol. 1, Supplement, p. 161.

§ 1·5462 grams required 39·37 c.c. $\frac{N}{10}$ KOH.

|| Jahrb. f. Chemie, vol. 7, p. 369.

¶ Zeit. f. Angew. Chem., 1897, p. 366.

The anilide is a white solid, fairly soluble in both alcohol and acetic acid, but more so in motor spirit, from which, however, it does not crystallize well.

The crystals from alcohol were large groups of fine needles, joined together in tree-like formation. The yield of the anilide was 55 per cent. of the theoretical.

On one occasion a sample of anilide crystallized from ethyl alcohol commenced to melt at 98·5°, but did not melt completely until a temperature of 118° was reached. After resolidification the sample melted sharply at the lower temperature; and the sample when crystallized from motor spirit also melted sharply at the lower temperature. There can be little doubt, therefore, that this anilide is dimorphous. The only other instance I can find of an anilide exhibiting dimorphism is that of acetanilide.*

Analysis of Cerotanilide.

Cal. for $C_{26}H_{51}O.C_6H_5NH$.	Found.
N = 2·97	2·66
C = 81·52	81·56
H = 12·10	12·32

Cerotone.—Two previous experimenters have worked upon the ketone of cerotic acid†: Brückner, by distilling the lead salt of cerotic acid, obtained a ketone melting at 62°; Nafzger, by the distillation of cerotic acid, obtained a ketone melting at 92°.

By applying the recently patented method of T. H. Easterfield and C. M. Taylor‡—namely, the heating of fatty acids with metallic iron, whereby stearic acid yields 80 per cent. of stearone—the ketone of cerotic acid was easily obtained. The details of the preparation are as follows: 9 grams of cerotic acid were heated for four hours with 0·69 grams of iron filings in an air bath slowly raised to a temperature of 340° to 350°. Carbon dioxide was evolved when the temperature had reached 280°. The temperature was now slowly raised until 340° was reached, and the air-bath was then regulated and maintained at this temperature for four hours.

The ketone thus obtained was purified by the following procedure: Iron was removed by boiling the ketone with dilute hydrochloric acid. Free fatty acid was then removed by boiling with dilute caustic soda. The soap thus formed was soluble in warm water, and was thus easily separated from the insoluble ketone. The ketone was now crystallized from motor spirit, and a pure product was obtained, which had a melting-point 93° C.

The melting-point was not changed by further crystallization from motor spirit or acetic acid. A 55-per-cent. yield was obtained by this method of preparation.

The ketone thus obtained is a white solid, fairly soluble in motor spirit and ethyl acetate, but sparingly soluble in acetic acid, from which it crystallizes in feathery flocculent masses. It is almost insoluble in hot alcohol, a saturated solution only becoming turbid on cooling.

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* Hans Meyer, "Analyse und Constitutionsermittelung Organ Verbindungen," p. 47.

† Beilstein, vol. 1, p. 1006.

‡ N.Z. patent 27607.

Analysis of Cerotone.

Calc. for $C_{51}H_{102}O$.	Found.
C = 83·83	83·50
H = 13·97	13·93

Cerotone Oxime.—This compound is new. It was prepared as follows: 1 gram of ketone was dissolved in 150 c.c. of amyl alcohol, and one and a half times the theoretical quantity of hydroxylamine hydrochloride, with an excess of caustic potash to decompose the hydrochloride, was added, and the alcohol then boiled under a reflux condenser for eight hours. It was found that unless prolonged boiling took place a poor yield of oxime was obtained. The hot solution was then filtered from the inorganic salts, and the filtrate allowed to crystallize. The crystals were filtered off, and recrystallized from ethyl acetate.

The oxime thus obtained melted at 77°, and the melting-point was not changed by further crystallization. The oxime is easily soluble in hot ethyl acetate and amyl alcohol, but is only sparingly soluble in hot alcohol. The crystals from the ethyl-acetate or motor-spirit crystallizations are groups of radiating needles.

Analysis of Cerotone Oxime.

Calc. for $C_{51}H_{103}N.O.$	Found.
N = 1·87	1·58
C = 82·14	82·15
H = 13·82	13·63

Henpentecontane 26 Ol.*

This secondary alcohol is new, and was obtained by reducing the ketone, dissolved in amyl alcohol, with metallic sodium. 0·3 grams of cerotone were dissolved in 150 c.c. amyl alcohol and boiled under a reflux condenser, while, at intervals, small pieces of sodium, of total weight 2 grams, were added over a period of five hours. The solution thus obtained was shaken out with water in a separating-funnel. The solid was filtered off and crystallized from ethyl acetate. The melting-point of the alcohol thus obtained was 97°, and was unchanged by further crystallization.

Henpentecontyl Acetate.—This compound was obtained from the above-mentioned secondary alcohol by boiling it with a large excess of acetic anhydride under a reflux condenser for six hours.

The alcohol gradually dissolved in the acetic anhydride, indicating that acetylation was taking place. The solution was filtered while hot, and the filtrate, on cooling, deposited the acetate as a white solid. This was recrystallized from acetic anhydride, and after drying over caustic potash in a vacuous desiccator, melted at 60·5–61·5°. The melting-point was unchanged by further crystallization.

Analysis of Henpentecontyl Acetate.

Calc. for $C_{53}H_{106}O_2$.	Found.
C = 82·17	81·89
H = 13·69	13·57

* "Henpentacontane" would sound more euphonious, but "henpentecontane" is philologically more correct.

It is interesting to compare S. Kipping's figures* for the secondary alcohol and acetates produced from ketones lower in the series with the data for henpentecontane 26 Ol. and acetate.

Acid.	Ketone.	Alcohol.	Acetate.	Difference, Alcohol and Acetate.
S. Kipping—Lauric	69°	75–76°	34–35°	41°
S. Kipping—Myristic	76–77°	80·5–81·5°	45–45·5°	35°
S. Kipping—Palmitic	82–83°	84–85°	47–49°	36·5°
Stearic	88°	89·5°‡	61°‡	28·5°
Cerotic	93°†	97°†	60·5–61·5°†	36°†
Montanic.. ..	97·5°†	101°‡	66°‡	35°

Ethyl Cerotate.—This compound was prepared from cerotic acid by dissolving the acid in absolute alcohol and boiling for twenty-four hours with 5 per cent. sulphuric acid. The ester obtained by this process was carefully washed free from sulphuric acid, dried in a vacuum, and then distilled under reduced pressure. The distillate crystallized from alcohol in colourless plates. It is easily soluble in alcohol, motor spirit and ethyl acetate, and acetic acid.

It boiled at 285° (14 mm.) and melted at 58·5–59°, and further crystallization did not raise the melting-point. Beilstein gives 59–60° as the melting-point of ethyl cerotate.

The following is a comparison of the melting-points of montanic and cerotic acids, and the melting-points of their ethyl esters :—

	Ethyl Ester.	Difference.
Cerotic acid (78°)	58·5–59°	18·75°
Montanic acid (83°)	67°	16°

Analysis of Ethyl Cerotate.

Calc. for $C_{28}H_{56}O_2$.	Found.
C = 79·24	79·14
H = 13·20	13·05

B. MONTANIC ACID AND DERIVATIVES.

In Part I the isolation of pure montanic acid was described, and it was shown that it had a melting-point of 83°, and had a molecular weight corresponding to a formula $C_{28}H_{56}O_2$.

Pure montanic acid crystallizes from acetic acid in colourless plates.§ It is fairly soluble in hot alcohol and glacial acetic acid, but is much more soluble in motor spirit and ethyl acetate.

Montanic acid is only slightly soluble in methyl alcohol. This fact is of interest, for, while cerotic acid is quite soluble in this solvent, melissic acid is said by Marie to be insoluble.

* Journ. Chem. Soc., 1893, p. 466.
† Determinations by the author.
‡ Private communication, T. H. Easterfield and C. M. Taylor.
§ Previous experimenters have reported montanic acid as crystallizing in needles.

Another feature of interest is the sparing solubility of the sodium soap in hot alcohol, for sodium cerotate dissolves without much difficulty.

Barium montanate is fairly easily soluble in hot ammoniacal alcohol, but calcium montanate is insoluble.

Montananilide.—This compound is new. It was prepared in a similar manner to cerotanilide. The pure anilide, after repeated crystallization, melted at 101·5°, and the melting-point was not changed by further crystallization.

Montananilide is soluble in those solvents mentioned for cerotanilide, but the solubility has decreased somewhat. It crystallizes from alcohol in groups of wavy needles.

The kjeldahl method was used for estimating the nitrogen.

Calc. for $C_{34}H_{61}O.N.$	Found.
N = 2·80	2·40

Montanone.—This ketone is new, and was prepared in a similar way to cerotone. The ketone, after repeated crystallization, melted at 97·5°, and the melting-point was not changed by further crystallization. A 50-per-cent. yield was obtained by this method of preparation.

Analysis of Montanone.

Calc. for $C_{55}H_{100}O.$	Found.
C = 83·96	83·91
H = 13·99	14·03

Montanone Oxime.—This compound was prepared in a similar way to cerotone oxime. The oxime, after repeated crystallization from ethyl acetate, melted sharply at 82·5°, and further crystallization did not raise the melting-point. Montanone oxime is a solid easily soluble in hot ethyl acetate, motor spirit, and amyl alcohol, but somewhat sparingly soluble in hot alcohol.

Analysis of Montanone Oxime.

Calc. for $C_{55}H_{111}O.N.$	Found.
N = 1·74	1·74

Ethyl Montanate.—This compound was prepared in a similar way to ethyl cerotate. The melting-point of ethyl montanate, after repeated crystallization from alcohol, was 67°, and this was unchanged by further crystallization. Ethyl montanate is a white solid, easily soluble in hot alcohol, from which it crystallizes in plates.

Analysis of Ethyl Montanate.

Calc. for $C_{30}H_{60}O_2.$	Found.
C = 79·64	79·41
H = 13·27	13·18

Methyl Montanate.—This compound was prepared by heating 200 c.c. absolute alcohol with 1 gram of montanic acid and 20 c.c. strong H_2SO_4 in sealed tubes maintained at a temperature of 110° for three days.

The methyl montanate crystallized out in glistening spangles, and was filtered off and purified, by removal of any free montanic acid, by precipitation as the calcium salt. The filtrate from the insoluble calcium salt deposited methyl montanate on cooling, and this was purified

by crystallizing from ethyl alcohol. Thus obtained, methyl montanate melted at 67–67·5°. The melting-point was not changed by further crystallization.

Methyl montanate is a white soft solid, soluble in hot ethyl alcohol, and less soluble in methyl alcohol. It crystallizes from both solvents in glistening spangles.

Montanamide.—This compound was prepared in small quantity by heating 0·880 ammonia with ethyl montanate for three days in a sealed tube. It began to melt at 109°, and was completely melted at 111°. The sample was too small for analysis.

C. MELLISIC ACID AND DERIVATIVES.

The melting-point of melissic acid obtained from montan wax was shown in Part I to be 88·5°. Schwalb* and Brodie† also give the melting-point of melissic acid prepared from beeswax as 88·5°. On account of the difficulty in obtaining melissic acid, only three derivatives could be prepared.

Melissone.—This ketone‡ was prepared from melissic acid obtained from both beeswax and montan wax. 0·5 grams melissic acid obtained from beeswax, and melting at 88·5°, was kindly placed at my disposal from laboratory stock.

Melissone was prepared in a similar way to cerotone and montanone. The ketone, after repeated crystallization, melted at 99·5–100°, and the melting-point was not changed by further crystallization. Melissone is a white solid, insoluble in the usual solvents, slightly soluble in hot ethyl acetate, and fairly soluble in amyl alcohol.

A 40-per-cent. yield was obtained by this method of preparation.

Calc. for $C_{59}H_{118}O$.	Found.
C = 84·08	84·42
H = 14·01	14·06

Melissone Oxime.—The small quantity of ketone remaining from the preceding preparation was utilized for the preparation of the oxime by a similar method to that employed in the case of cerotone and montanone oximes.

The oxime, after repeated crystallization from ethyl acetate, melted at 84°. The sample was too small for analysis.

Melissanilide. — This compound was prepared from melissic acid, derived from montan wax, in a similar way to the anilides of cerotic and montanic acids. The anilide, after crystallization from acetic acid and ethyl acetate, melted at 103°, and the melting-point was unchanged by further crystallization.

Melissanilide is a white compound easily soluble in ethyl acetate and motor spirit, and fairly soluble in alcohol.

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* Annalen, 235, p. 135.

† Phil. Trans. Roy. Soc., 1848.

‡ Schwalb—"Non-acid Constituents of Beeswax" (Journ. Chem. Soc., 1885)—mentions that a ketone melting at 97–99° is produced during the potash-lime fusion of myricyl alcohol.

Table I.—Comparison of the Melting-points of the Anilides and Amides of some Fatty Acids.

Acid.		Amide.	Anilid.	Difference, Amide and Anilid.
62°	Palmitic C_{16} ..	101°	90°	11°
69°	Stearic C_{18} ..	109°	94	15°
	Arachidic C_{20} ..	108° (Feleto and Ponzio)	..	..
	Behenic C_{22} ..	111° ,,	..	..
78°	Cerotic C_{26} ..	109° (Marie)	*98·5°	10·5°
83°	Montanic C_{28} ..	*109–111°	*101·5°	8·5°
88·5°	Melissic C_{30} ..	116° (Marie)	*103	13°

Table II.—Comparison of the Melting-points of the Oximes and Ketones of some Fatty Acids.

Acid.	Melting-point.	Ketone.	Oxime.	Difference, Ketone and Oxime.
Caproic	−1·5°	14·6°	..	..
Caprylic	16·5°	40·5°	20°	20·5°
Capric	31·5°	58°	..	..
Lauric	43·6°	69°	40°	29°
Myristic	53·8°	76–77°	47–48°	29°
Palmitic	62°	82–83°	57–58°	25°
Stearic	69°	88°	63°	25°
Cerotic	*78°	*93°	*77°	16°
Montanic	*83°	*97·5°	*82·5°	15°
Melissic	*88·5°	*99·5–100°	*84°	15·75°

As the series is ascended the higher members have a smaller difference in melting-point between ketone and oxime than lower members.

Table III.—Summary of Physical Constants obtained for Cerotic, Montanic, and Melissic Acids.

Melt. Pt.	Acid.	Anilide.	Ketone.	Oxime.	Amide.	Ethyl Ester.	Methyl Ester.
*78°	Cerotic ..	*98·5°	*93° ..	*77°	109° (Marie)	*58·5–59° ..	66° (Marie)
*83°	Montanic	*101·5°	*97·5° ..	*82·5°	*111° ..	*67° ..	*67–67·5°
*88·5°	Melissic ..	*103°	*99·5–100°	*84°	116° (Marie)	75° (Marie)	74·5° (Marie)

* Determinations by the author.

Part III.—Constitution of the Higher Fatty Acids.

It has been shown in Part I that three acids—cerotic, montanic, and melissic—exist side by side in montan wax. It was also shown in Part II that the properties of these three acids are closely related, and that their corresponding compounds are similar. It would hardly seem likely that three such compounds, possessing properties so closely related, should exist side by side in montan wax unless there be some simple constitutional relationship between them.

Experiments have been made to show the relation of these acids to one another and also to acids lower in the series.

(A.) *The Relationship to Acids Lower in the Series.*

Mai* showed that when the barium salts of palmitic or stearic acid were distilled with sodium methylate, hydrocarbons resulted. From barium palmitate he thus obtained n.-pentadecan and from stearic acid n.-heptadecan.

If barium montanate is heated with sodium ethylate, it should, if it behaves like palmitate and stearate of barium, give a hydrocarbon, n.-heptacosane, $C_{27}H_{56}$.

If this hydrocarbon is a normal primary paraffin it will be identical with the compound obtained by Krafft by the reduction of myristone, and montanic acid will then also contain a normal primary chain of carbon atoms. It will still remain uncertain whether the carboxyl group is at the end of the chain, for though the ease of bromination suggests that the bromine enters the chain in the α position, it does not show that the carboxyl group is at the end of the chain (isobutyric acid brominates more readily than normal butyric acid).

Calcium montanate when distilled with sodium ethylate gave a hydrocarbon, which after recrystallizing melted at 56·5–57·5°. A sample of normal heptacosane prepared by the reduction of the myristone with hydriodic acid melted at 59–60°. When equal quantities of the two hydrocarbons were mixed the product melted at 58–59°—*i.e.*, half-way between the two. There can, under these circumstances, be little doubt that the hydrocarbon from montanic acid was only slightly impure n.-heptacosane, otherwise the mixture would have melted almost for a certainty at a lower temperature than the melting-point of the lower melting-point hydrocarbon.

(B.) *The Relationship existing between the Three Higher Fatty Acids.*

Attempts were made to degrade montanic acid to cerotic acid, but, although much work was done in this direction, no definite conclusion has been arrived at. It was hoped that degradation would be effected by the following procedure, which is based on that employed by Le Seur in the degradation of stearic acid*: (*a*) Formation of α brommontanic acid; (*b*) production of the unsaturated acid direct, or the formation of the α hydroxy acid and the conversion of this compound into the unsaturated acid; (*c*) the oxidation of the unsaturated acid into the lower homologue.

* Berichte, vol. 22, 1889, p. 2133.

The first step (*a*) took place without difficulty ; in step (*b*) the α hydroxy acid was readily obtained, but all attempts to prepare the pure unsaturated acid were unsuccessful, and step (*c*) could not therefore be attempted.

Le Seur,* in the degradation of stearic acid to palmitic, also experienced considerable difficulty in the isolation of pure unsaturated acid (Δ^{α} oleic acid). He only obtained a 10-per-cent. yield.

The following is a brief description of the compounds isolated and the experiments made in connection with the degradation of montanic acid to cerotic :—

Brommontanic Acid.—Hell and Sadomsky's method† was used for the preparation of this compound. 6 grams of ethyl montanate were ground with 0·19 grams of dried red phosphorus, which had been previously freed from phosphorous acid by repeated washing with water. Anhydrous bromine was now added drop by drop to the mixture contained in a flask. There was no violent action such as Le Seur records in the case of the formation of bromstearic acid. The contents of the flask were then warmed on the water bath for two hours under a reflux condenser. The condenser was now removed, and the excess of bromine allowed to escape. The molten mass thus obtained was poured into cold water. The crude brommontanic acid was melted twice in fresh water to decompose any acid bromide.

The crude brommontanic acid was then crystallized from acetic acid and motor spirit. By this means a pure compound was obtained, which melted at 75° C. The melting-point did not change on further crystallization.

Brommontanic acid crystallizes from acetic acid in colourless hexagonal plates. It is easily soluble in acetic acid and motor spirit ; the yield obtained after two crystallizations was 60 per cent. of the theoretical.

Calc. for $C_{28}H_{55}BrO_2$.	Found.
Br. = 15·90	15·81

Attempts to remove hydrobromic acid from brommontanic acid by means of pyridine, quinoline, and a concentrated solution of caustic potash did not result in the production of the unsaturated acid, as had been expected.

The hydroxy acid could easily be obtained, mixed with the unsaturated acid, by the action of 30-per-cent. alcoholic potash on brommontanic acid, but all attempts to remove water from it by means of ortho-phosphoric acid which had previously been heated to 200° were unsuccessful.

In conclusion, the author wishes to thank Professor Easterfield for suggesting this subject for research, and also for much practical advice, without which the writer could not have undertaken this investigation.

* Journ. Chem. Soc., 1904, p. 1708.
† Berichte, vol. 24, 1891, p. 2390.

Art. XXX.—*The Chemistry of Bush Sickness.**

By B. C. Aston, F.I.C., F.C.S.

[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

The mysterious wasting condition locally known as "bush sickness," which always eventually appears in ruminating herbivora pastured on certain areas of pumice country in the North Island situated near the intersection of the 38th parallel of E. latitude and the 176th meridian of S. longitude has been the subject of much consideration for the past fourteen years, though it is only within the last two years that any adequate provision has been made to submit the matter to systematic research. From the references given at the end of this paper one may find the little that is known regarding the veterinary aspect of the matter. It is desired here, at the direction of the Minister of Agriculture, to record some facts which have been elucidated through the chemical analysis of sundry specimens which I from time to time have collected or received. The reasons why the matter should be referred to a chemist to investigate are given in an article in the "Journal of the New Zealand Department of Agriculture" for November, 1911 (vol. 3, No. 5).

An ordinary analysis of the soils of the affected district does not show any reason why stock should not thrive on the herbage grown by these soils. In Table 6 are given the total amounts of constituents of the soil obtained by breaking up the silicates with hydrofluoric acid. The manganese is perhaps high for New Zealand soils, but Hilgard quotes analyses of American soils with a greater percentage (see p. 372, "Soils"). Table 5 gives the chemical analysis as ordinarily stated for agricultural purposes. Analyses of grass-ashes are given in Table 1. In considering these results it must be remembered that they do not give constituents which may be present in amounts less than one-hundredth of 1 per cent., such as copper, barium, &c., and that it is possible that some of these constituents if taken up by the herbage might affect the health of beasts pastured thereon. To obtain a clue as to what element may exist in soil and grass that would produce bush sickness it is necessary to systematically examine many animal specimens, and it is this work which is being given first place in the research.

As the symptoms of bush sickness would accord with those produced by chronic mineral poisoning, one of my first experiments was to examine the liver of a sick animal for traces of heavy metals. To my astonishment, I obtained a considerable quantity of copper from the ash of a liver from a steer which was killed under veterinary supervision as being a typical bush-sick animal. On consideration it appeared possible that copper

* "Bush sickness" occurs in ruminants pastured on land which has been recently reclaimed from forest, or on open country which has been laid down in English pasture for over twenty years. Veterinarians can detect no abnormal micro-organisms or signs of disease in the wasting animal. Affected animals recover as soon as they are moved on to healthy country. The affection is confined to a definite area of pumice country, outside of which it does not spread, but within the area the sickness always in time (a few months in sheep, longer in cattle) develops in cattle and sheep. The affected area grows an abundance of green pasture—English grasses and clovers—at all times of the year, and yet the animals become emaciated, and eventually die if not removed. Ruminants from other parts of the country on being placed on "sick" country experience decided benefit for the change and fatten for a time. Horses fed for years continuously and entirely on the affected pasture are not injuriously affected.

might have dropped into the sample while it was being dried, there being always a certain amount of copper and brass dust in most laboratories. For the work a room was therefore set aside in which copper utensils, brass bunsens, and all apparatus containing copper were rigidly excluded, and any brass fittings were coated with varnish. Further specimens were obtained and analysed, great care being taken to guard against adventitious entry of copper into the assay. The results of analysis of these specimens are given in Tables 3 and 4. They show that there is always an excess of copper (compared with the amounts found by the authorities quoted below) in the livers of sheep suffering from bush sickness, although when these livers are extremely fatty the copper is diminished; but if calculated on the dried fat-free liver the percentage is always excessive. Analyses of the livers of healthy sheep killed for consumption have shown, however, that a comparatively large amount of copper in the liver is quite consistent with health. Further, on dosing sheep and cattle with copper-acetate for over a year their livers were found to take up much larger amounts of copper than any liver hitherto examined without producing any of the final symptoms of bush sickness. Feeding experiments conducted by Mr. H. A. Reid, F.R.C.V.S., at Wallaceville Laboratory, in which copper-acetate in small doses was given with the food to sheep, showed that the liver could absorb large amounts of copper and remain healthy. The greater part of the copper was no doubt eliminated in the faeces. Some of the sheep died of a braxy-like disease, but others remained healthy, and the experiments were discontinued after they had been going on for seventeen months. Experiments with calves and rabbits extending over a similar period yielded negative results, which supports the experiments of du Moulin (Journ. Pharm., 5, 13, p. 189; abst. in J.C.S., 1883, p. 483), who gave doses of from ½ gram to 1 gram of copper-subacetate every day for six weeks to dogs and rabbits without producing poisonous effects. The bulk of the evidence at present is against the hypothesis that copper is a causative agent in producing bush sickness, but the results obtained are so full of interest that it is deemed advisable to publish them at this stage.

Copper is certainly a normal liver constituent in sheep and cattle. Wynter Blyth ("Poisons," 1895, p. 613) states that a sheep's liver contains 1 part of copper in 20,000 (0·005 per cent.), and quotes Dupré's statement that in the kidneys and livers of ruminants copper may always be found. Professor Malcolm informs me that the liver of the ox normally contains 0·00225 to 0·0051 per cent. copper. Professor Gilruth refers to articles by Lehman (Arch. f. Hygiene) in which the author gives 0·0048 as the percentage of copper in dried ox-liver. In sheep normally he found 0·0018 per cent. in the dried liver, but in copper districts only half that quantity in the liver but five times that quantity in the heart. Analysis of hearts from bush-disease areas do not show any such excess of copper.

Ellenberger and Hofmeister (Beid. Centr., 1883, pp. 606–9; abst. in J.C.S., 1884, p. 474) experimented with sheep, giving doses of ½ gram to 3 grams. Among the negative results they obtained were no alteration of the muscular structure, no acceleration of the motion of the heart, no uniform alteration in the microscopic appearance of the blood-corpuscles, no alteration of the respiration nor of the secretion of the urine. Amongst the positive results were the presence of albumen, blood, and bile in the urine, flaccidity of the muscles, weakness, and loss of appetite. They note that the excretion of copper from the system is chiefly by the

bile, partly by the urine but in lesser degree; that the liver retains the copper with great tenacity and the pancreas with almost equal strength, and that the kidneys do not retain it as much as the other two organs. The nervous and muscular systems do not contain enough to interfere with their action. They recommend numerous small doses in order to obtain chronic effects. My experiments show that the pancreas does not contain much copper. Max Klemptner (Chem. Centr., 1894, ii, 620; abst. in J.C.S., 1895, p. 321) records the following symptoms in poisoning by sodium cupric tartrate: Atrophy both in acute and chronic cases; diarrhoea some time before death, and persistent vomiting, in chronic cases; enfeebled pulse and laboured respiration. When subcutaneously injected into the pleura the salt produces weakness and stiffness of the hinder extremities; the same is noticed when the salt or copper haemoglobin is exhibited. In one case blood and albumen were found in the urine. Copper was not found in the blood serum, but in the corpuscles.

The question whether chronic copper poisoning can occur in animals is evidently doubted by many authorities. A. Koldeway (Chem. Centr., 1896, ii, 1041; abst. in J.C.S., 1898, p. 39) states that no noteworthy evil results follow small doses of copper (or even large doses) in people in good health, or in animals that vomit readily; long continuance in the use of copper, however, produces slight degenerative changes in the liver and kidneys, which can only be detected on microscopic examination. He doubts the existence of chronic copper poisoning amongst workers in that metal, any illness occurring probably being due to other metallic impurities of the copper. L. Lewin (Deusch Med. Wochenschr., 1900, 26, 689; abst. in J.S.C.I., 19, 1900, 1183) could not discover any phenomena indicating chronic poisoning in copper-workers. The editor of Taylor's "Medical Jurisprudence" (1905, p. 476) is evidently doubtful as to whether chronic copper poisoning can occur in human subjects. This doubt should be even greater as to whether the poisoning can occur in herbivora.

Dieulafait (Compt. Rend., 89, 453: abst. in J.C.S., 1879, p. 1020; 1880, p. 489) states that copper occurs in all plants that live on primary rocks, or on soils derived from those rocks. One hundred grams of rock will always give a reaction for copper. Dupré (Analyst, ii, 1; abst. in J.C.S., 1877, p. 511) states that copper is found in all vegetables as well as in animals, but rarely amounts to more than 1 gram per 100,000 (0·001 per cent.). Dieulafait states that 1 gram of ash from all plants growing on primordial rocks give the copper-reaction, but plants grown on pure limestone contain but traces of copper, requiring at least 100 grams of ash for its detection. J. B. Harrison, in a recent report (1906) to the Science and Agricultural Department of British Guiana, shows its occurrence in hundredths of 1 per cent. in many igneous rocks of that colony, and Hillebrand ("Analysis of Silicate and Carbonate Rocks," Washington) considers that it can be found almost invariably if looked for in the rock-analysis carried out by the United States Survey Laboratory, but it is seldom reported unless extra precautions have been taken to prevent its entry into the analysis.

The few determinations which have been made of copper in the soil and grass-ash of the affected country go to show that it exists in amounts of the order of thousandths of 1 per cent. rather than of hundredths.

I have not been able to consult any of the original papers, owing to the difficulty in obtaining scientific literature in New Zealand. One is unable to conjecture how many specimens were analysed to supply the above data, and whether the figures might be taken as a standard.

It having been decided to carry on an extensive series of field experiments with a view to ascertain whether top-dressing the pasture with various ertilizers would in any way mitigate or prevent development of the sickness, the following substances recommended by me were applied as top-dressings to different paddocks on which the animals were subsequently grazed: Basic slag, superphosphate of lime, rock phosphate, ferrous sulphate, caustic lime, carbonate of lime, nitrate of calcium, potassium-sulphate, blood and bone manure, agricultural salt. Both cattle and sheep were used in these experiments. Rock-salt has been given in most cases freely as a lick. On some experiments water has been given to sheep, and on other experiments no water was given. To cattle water was usually given.

The results of these experiments, which were conducted under veterinary supervision, will be published in due course. One interesting feature may be mentioned. The sheep which died of "bush sickness" on these experimental plots provided with a plentiful supply of salt developed abnormally fatty livers, as the analysis shows. The liver was mainly fat and water. This occurred when the sheep were supplied with water, as at Mamaku, and without, as at Te Pu. It will be noted that the time the sheep were enabled to live on the affected pasture was unusually long.

The writer desires to acknowledge his indebtedness to Dr. Reakes, Director of the Live-stock Department, for affording information and every facility for carrying on the work, and to Dr. Maclaurin, Dominion Analyst, for permission to visit frequently the affected district. Messrs. Clayton, Lyons, Reid, and Kerrigan, Veterinary Officers of the Department, have proved of great help; Professors Gilruth (Melbourne), Marshall (Dundee), and Malcolm (Dunedin), have provided many references and much valuable advice. Mr. R. Alexander, with his practical knowledge in the field, and Messrs. John Chilwell, F.I.C., and Theodore Rigg, M.Sc., in the laboratory have also rendered valuable assistance.

Experimental.

In the analysis of animal specimens for copper the method recommended by Raoult and Breton (Compt. Rend., 85, 40–42; abst. in J.C.S., 32, 1877) was used. The substance (about 100 grams wet or 30 grams dry) is heated in a porcelain dish with sulphuric acid until the mass is carbonized. The charred mass is heated to redness in a muffle furnace, and in great part burnt in a good current of air. When the combustion becomes difficult in consequence of the fusion of phosphates (chiefly phosphate of iron in the liver specimens) it is exhausted with a small quantity of nitric acid and water. The filtered residue is again incinerated, and the operation repeated until a pure ash is obtained, which is exhausted with more nitric acid. The acid filtrates are evaporated and the nitric acid expelled by evaporating to dryness and taking up with hydrochloric acid. The diluted solution of the ash is now subjected to a current of sulphuretted hydrogen until the copper-sulphide separates out well. This is filtered and incinerated. The ignited residue is redissolved and filtered from any impurity (silica). The solution is made up to a known volume, and an aliquot part taken for colorimetric estimation of the copper by the well-known ferro-cyanide method. The result is always checked by a gravimetric determination made on another aliquot portion. The results agree very closely. I can indorse Raoult and Breton's warning as to the necessity of pushing the incineration till an ash free from carbon remains. Carbon appears to retain the copper with great tenacity.

Table 1.

Analysis of Ash of Cocksfoot (Dactylis glomerata), *in Flower.*

—	Watt's Dictionary, vol. 2, p. 943.	With Ripe Seed, Watt's Dictionary.	Meadow Grass, Watt's Dictionary.	M221–2. Grass from Bush-disease Country.	Hay from Te Puke.
Potassic oxide (K_2O)	29·52	33·06	22·13	15·01	16·45
Calcic oxide (CaO)	5·82	8·14	9·13	5·25	8·90
Magnesic oxide (MgO)	2·22	3·47	2·49	3·36	4·07
Ferric oxide (Fe_2O_3)	0·59	0·23	0·62	0·93	0·72
Sulphuric anhydride (SO_3)	3·52	3·96	4·23	3·44	2·45
Silicic oxide (SiO_2)	26·65	32·18	34·11	42·86	36·92
Carbon-dioxide (CO_2)	2·09	2·88	1·15	2·93	6·57
Phosphoric anhydride (P_2O_5)	8·60	6·41	5·56	3·83	3·79
Potassic chloride (KCl)	17·86	4·87.	17·40	11·04	16·19
Sodic chloride (NaCl)	3·09	4·76	3·14	4·10	4·07
Manganese-oxide (Mn_3O_4)	..	..	..	0·97	..
Carbon and undetermined	..	..	..	5·90	..
Alumina	..	..	..	0·38	..
	99·96	99·96	99·96	100·00	100·13
Ash in 100 parts fresh substance	1·59	2·61	..	..	..
,, dry substance	5·31	5·51	..	..	..
Sulphur in 100 parts dry substance	2·37	2·48	..	..	..
Ash of grass dried at 100° C.	..	..	..	..	8·47

Table 2.

Analyses of Healthy and Unhealthy Bloods.

—	Healthy Carotid Artery of Steer, Waiwetu, G9.	Unhealthy Carotid Artery of Steer, F504.	F504, reduced as 7·43 : 4·2.
Ash—			
Total ash	4·20	7·43	..
Insoluble in water	12·00	12·71	..
Soluble	88·00	87·29	..
Silica	1·06	2·77	1·55
Sodic chloride	52·07	58·35	32·68
Phosphoric anhydride	4·75	3·05	1·71
Calcic oxide	1·01	1·68	0·94
Magnesic oxide	0·49	0·82	0·46
Ferric oxide	7·64	3·80	2·12
Sulphuric anhydride	6·13	6·90	3·86
Potassic oxide	6·55	3·99	2·23
Sodic oxide	11·49	11·25	6·28
Carbon-dioxide	8·81	7·39	4·24
Percentage of ash constituents in the dried blood—			
Silica	0·044	0·205	0·115
Sodic chloride	2·168	4·322	2·416
Phosphoric anhydride	0·200	0·220	0·123
Calcic oxide	0·042	0·124	0·065
Magnesic oxide	0·020	0·060	0·034
Ferric oxide	0·318	0·281	0·157
Sulphuric anhydride	0·255	0·510	0·285
Potassic oxide	0·283	0·298	0·167
Sodic oxide	0·478	0·833	0·467

TABLE 3.

Cattle Specimens.

Lab. No.	Description of Sample. Animal.	Organ.	Weight.	Post-mortem conducted by	Percentage of Copper (Cu). Wet Sample.	Sample dried at 100°C.	Remarks.
	Sick steer	Liver ..	..	..	..	0·024	
M 385	Sick white cow (T) ..	,, ..	8¾ lb.	Dr. Reakes.. ..	..	0·005	Liver very fatty. Killed.
	,, ..	Kidneys ..	750 grm.	,, ...	..	0·003	
	,, ..	Heart ..	..	,, ...	..	0·003	
388	Sick steer (S)	Liver ..	..	,, ...	..	0·010	Killed, 27/7/10, when recovering on clean country.
	,, ...	Heart ..	..	,, ...	..	0·003	
387	Sick white calf	Liver ..	3 lb. 1 oz.	,, ...	..	0·025	Killed, 25/7/10.
389	Healthy steer	,, ..	..	Abattoir Inspector ..	0·003	0·011	
390	,, ...	,, ..	..	,, ..	0·002	0·007	70 per cent. water in liver.
398	Sick steer	,, ..	..	H. A. Reid, F.R.C.V.S.	0·006	..	Killed, July, 1911.
399	Sick cow (A)	,, ..	..	,,	..	0·011	,, ,,
400	,, (T)	,, ..	..	,,	0·004	..	Liver very fatty. Killed, 25/7/11.
	,, ...	Pancreas ..	277 grm.	,,	0·00013	..	
401	Healthy calf (4 months) ..	Liver ..	..	Abattoir Inspector ..	..	0·006	
774	Sick steer (A)	,, ..	8 lb.	Dr. Reakes.. ..	..	0·012	
	,, ...	Brain ..	280 grm.	,, ...	0·00031	..	
	,, ...	Pancreas ..	547 grm.	,, ...	Trace	..	
775	,, (McN) ..	Liver ..	5 lb. 9 oz.	,, ...	0·004	0·014	Liver not fatty.
	,, ..	Brain ..	1 lb.	,, ...	0·0003	..	Brain fatty.
O 44	Sick cow (S)	Liver ..	2,682 grm.	Collins and Reid ..	0·0024	0·008	72·7 per cent. water in liver.
51	,, (M)	Milk ..	..	None	..	0·0012	0·84 per cent. calculated on ash.
124	,, ...	,, ..	..	,, ...	..	0·0015	
*149*a*	Healthy calf (small) ..	Liver ..	2,278 grm.	H. A. Reid, F.R.C.V.S.	0·025	0·090	72·3 per cent. water in liver.
	,, ,, ..	Spleen ..	355 grm.	,,	0·0004	0·0017	76·8 per cent. water in liver.
	.. ,, ..	Faeces ..	..	,,	0·0035	0·018	81·06 per cent. water in faeces.
*167*b*	,, (large) ..	,, ..	..	,,	0·0013	0·008	85·00 per cent. water in faeces.
	,, ,, ..	,, ..	..	,,	0·004	..	
*149*a*	,, (small) ..	,, ..	..	,,	0·003	..	
	,, ,, ..	Pancreas ..	..	..	..	0·0009	
	,, (both) ..	Urine ..	..	..	..	0·0005	
146	Diseased cow	Liver ..	3,202 grm.	..	0·003	0·011	74·2 per cent. water in liver, and 0·5 per cent. fat.

* These two calves were dosed with copper-acetate solution, receiving 40 c.c. per day of a solution containing 0·958 per cent. copper (Cu) from 26/8/10 until one was killed on 14/8/11. Microscopic examination of liver showed dilatation of the interlobular vein and the capillaries. Kidneys, slight catarrh of the renal epithelium. Animal otherwise normal and healthy.

TABLE 4.

Sheep Specimens.

Lab. No.	Description of Sample. Animal.	Organ.	Weight.	Post-mortem conducted by	Per-centage of Water at 100°C.	Percentage of Copper (Cu). Wet Sample.	Sample dried at 100°C.	Remarks.
			Grm.					
	Sick sheep (C) ..	Liver ..	900	Dr. Reakes ..	..	0·0072	..	One five-year-old wether. Killed, 23/7/10.
	,, ..	Gall and kidneys	638	,, ..	..	0·0084	..	Two six-year-old ewes.
M 392	Healthy sheep (Ng) ..	Liver, gall, and kidneys	925	Inspector	74	0·0155	..	Oxydized by $KClO_3$ and HCl.
393	,, ..	Ditto ..	949	,, ...	74	0·00285	..	Carbonized by H_2SO_4.
394	,, ..	Liver ..	818	,, ...	..	0·019	..	
776	Sick sheep (D) ..	,, ..	560	Dr. Reakes ..	..	..	0·066	Killed, 16/12/10. Carbonized by H_2SO_4.
777	,, ..	,, ..	504	,, ..	..	..	0·114	Ditto.
789	Sick lamb (M) ..	Brain ..	..	W. T. Collins, M.R.C.V.S.	..	..	..	Merest trace of copper.
777	Sick sheep (D) ..	Heart ..	..	Dr. Reakes	..	..	0·0051	Killed, 16/12/10.
789	Sick lamb (M) ..	Liver ..	431	W. T. Collins, M.R.C.V.S.	..	..	0·031	Killed, 6/3/11.
793	,, (McN) ..	,, ..	..	R. Alexander ..	..	0·011	0·046	
	,, ..	Heart ..	60	,, ..	..	0·00041	..	
	,, (G) ..	Liver ..	600	B. C. Aston ..	72·5	0·007	0·0213	Killed, 6/12/10.
	,, ..	Brain ..	..	,, ..	..	..	..	Manganese present in brain.
	,, ..	Heart ..	..	,, ..	..	0·0004	..	
794*b*	Sick ewe	Liver ..	740	,, ..	71·0	..	0·049	
814	Healthy sheep (S) ..	,, ..	480	..	..	..	0·011	
815	,, ..	,, ..	490	..	..	..	0·005	
794*a*	Sick ewe (G) ..	,, ..	..	..	..	..	0·04	
817	Sick lamb (G) ..	,, ..	680	..	..	..	0·016	
O 47	Healthy lamb (D) ..	,, ..	803	..	70·12	0·020	0·066	Killed, 9/5/11 } These four animals
48	,, ..	,, ..	665	..	71·32	0·013	0·045	,, ,, } were fattened on
49	,, ..	,, ..	759	..	69·70	0·006	0·019	,, ,, } the sick country and
50	,, ..	,, ..	633	..	66·61	0·004	0·013	,, ,, } killed for human consumption.

40	Healthy sheep (Sh)	„	641	..	69·60	0·019	0·063	
41	„ ..	„	703	..	70·70	0·022	0·073	
42	Sick sheep (H) ..	„	431	W. T. Collins, M.R.C.V.S.	72·00	0·034	0·121	
43	Sick lamb (M) ..	„	536	„	61·60	0·0084	0·021	Liver fatty.
46	Sick ewe (H) ..	„	630	Collins and Reid ..	73·24	0·016	0·059	
M 258	Wool-ash	..	..	..	..	..	0·0024	Percentage of copper in ash.
O 68	Healthy wether (Msn)	Liver ..	549	Inspector Gillies ..	65·50	0·009	0·026	O 68–73 are Romney cross wethers, 4-tooth, in good condition. Killed, 9/6/11. From Bideford district, near Masterton.
69	„ ..	„ ..	630	„ ..	68·40	0·001	0·034	
70	„ ..	„ ..	753	„ ..	68·30	0·006	0·019	
71	„ ..	„ ..	731	„ ..	66·70	0·013	0·040	
72	„ ..	„ ..	731	„ ..	68·00	0·004	0·012	
73	„ ..	„ ..	646	„ ..	66·20	0·014	0·045	
82	Healthy sheep (Gn) ..	„ ..	655	Vet. Surgeon Burton	63·70	0·010	0·028	O 82–89 are from Gisborne district.
83	„ ..	„ ..	606	„	65·40	0·010	0·028	
84	„ ..	„ ..	615	„	60·00	0·016	0·040	
85	„ ..	„ ..	660	„	63·20	0·007	0·020	
86	„ ..	„ ..	497	„	60·40	0·012	0·029	
87	„ ..	„ ..	517	„	62·10	0·010	0·027	
88	„ ..	„ ..	717	„	64·60	0·008	0·023	
89	„ ..	„ ..	786	„	60·70	0·021	0·054	
91	„ (Hs) ..	„ ..	723	..	65·10	0·0005	0·0014	91, 92, and 95 are four-year-old Romney cross-breeding ewes; 93, 94, and 96 are four-year-old Romney cross wethers; from Hastings district. Killed, 20/6/11.
92	„ ..	„ ..	458	..	66·10	0·008	0·024	
93	„ ..	„ ..	653	..	67·70	0·013	0·041	
94	„ (Nr) ..	„ ..	648	A. Barnes, M.R.C.V.S.	69·0	0·003	0·011	
95	„ ..	„ ..	858	„	60·3	0·021	0·053	
96	„ ..	„ ..	530	„	67·1	0·005	0·016	
114	Healthy wether (Is) ..	„ ..	601	R. Finch, M.R.C.V.S.	68·2	0·003	0·010	Two-year-old crossbred Leicester wethers, from Little River, Canterbury district. Killed, 27/6/11.
115	„ ..	„ ..	522	„	68·5	0·007	0·022	
116	„ ..	„ ..	586	„	67·4	0·035	0·010	
117	„ ..	„ ..	574	„	69·8	0·001	0·004	
118	„ ..	„ ..	439	„	69·1	0·001	0·004	
119	„ ..	„ ..	602	„	64·2	0·001	0·004	
120	„ ..	„ ..	645	„	63·3	0·0004	0·001	
121	„ ..	„ ..	490	„	68·1	0·006	0·021	
126	Sheep dosed with copper-acetate	„ ..	345	H. A. Reid, F.R.C.V.S.	72·8	0·114	0·422	Died, 25/7/11. Received 12 cc. copper-acetate solution, containing 0·958 per cent. copper (Cu), from 6/5/10 till its death.

TABLE 4—*continued.*

Sheep Specimens—continued.

Lab. No.	Description of Sample.			Post-mortem conducted by	Percentage of Water at 100° C.	Percentage of Copper (Cu).		Remarks.
	Animal.	Organ.	Weight.			Wet Sample.	Sample dried at 100° C.	
			Grm.					
O 185	Sheep	Liver ..	1,120	J. Kerrigan, M.R.C.V.S.	51·15	0·0166	0·034	Contained 36·6 per cent. fat. Died on super. and lime plot, Mamaku, 10/11/11.
186	,, ...	,, ..	616	,,	51·90	0·0057	0·012	Contained 36·1 per cent. fat. Died on limed paddock, Te Pu, 10/11/11.
187	,, ...	,, ..	560	,,	63·70	0·0220	0·061	Contained 21·3 per cent. fat. Died on limed paddock, Te Pu, 10/11/11.
188	,, ...	,, ..	644	,,	43·60	0·0163	0·029	Contained 47·15 per cent. fat. Died on nitrate-of-lime plot, Te Pu, 10/11/11.
193	,, ...	,, ..	397	,,	62·80	0·0060	0·016	Contained 28·5 per cent. fat. Died on super. paddock, Mamaku, October, 1911.
190	,, ...	,, ..	536	,,	66·00	0·0150	0·044	Contained 17·7 per cent. fat. Died on limed plot at Te Pu, 14/11/11.
190*b*	,, ...	,, ..	700	,,	69·90	0·0140	0·046	Contained 5·05 per cent. fat.
	,, ...	,, ..	464	,,	63·5	0·0140	0·039	Died on Te Pu slag paddock, 29/11/11.
	,, ...	,, ..	702	,,	50·2	0·006	0·012	Contained 36 per cent. fat. Died at Te Pu paddock, 5/10/11.
					48·5	0·006	0·012	Contained 39·3 per cent. fat.
194	,, ...	,, ..	586	,,	63·5	0·014	0·039	Contained 17·7 per cent. fat. Died at Te Pu.

NOTE.—The specimens O 185 to O 190*b* are from animals from the experimental plots. They died from "bush sickness," having been on the plots since January, 1911, at Te Pu, and February, 1911, at Mamakau, respectively. The fat is calculated on the wet sample.

TABLE 5.

Results, except One, are the Percentages calculated on Soil dried at 100° C.

Lab. No.	Locality.	Description.	Chemical Analysis.										Mechanical Analysis.						
			Volatile Matter.		Total Nitrogen.	Citric-acid Extraction.		Reaction to Litmus.	Hydrochloric-acid Extraction.				Capillarity.	Capacity for holding Water.	Coarse Sand.	Fine Sand.	Silt.	Fine Silt.	Clay.
			At 100°C.	At Red Heat.		Potash (K_2O).	Phosphoric Acid (P_2O_5).		Lime (CaO).	Magnesia (MgO).	Potash (K_2O).	Phosphoric Acid (P_2O_5).							
L 1121	Open fern country	Coarse sand	11·0	18·9	0·39	0·026	0·017	Neutral ..	0·26	0·11	0·07	0·15	Very good	Excellent	20·0	52·5	5·6	4·6	9·0
1122	Forest, Mamaku	,,	17·2	16·2	0·38	0·015	0·013	Faintly acid	0·11	0·06	0·07	0·10	Poor ..	Very good	29·0	39·9	4·1	3·7	10·9
1123	,,	,,	15·6	12·9	0·24	0·010	0·010	Neutral ..	0·17	0·06	0·07	0·08	Very good	Excellent	24·0	39·5	3·5	3·5	9·1
520	Rotorua ..	..	5·2	8·1	0·20	0·012	0·011	,, ..	0·11	0·08	0·07	0·10	,,	Good ..	31·0	47·2	7·9	4·7	5·8
521	,, ..	,,	6·5	8·0	0·21	0·012	0·018	,, ..	0·20	0·30	0·11	0·15	Good ..	,, ..	29·0	48·1	6·5	5·0	10·1
522	,, ..	..	3·9	5·6	0·13	0·012	0·016	Faintly acid	0·34	0·35	0·16	0·07	Fair ..	,, ..	31·0	43·2	9·9	6·5	6·6
G 37	Arahiwi ..	..	14·8	14·9	0·42	0·038	0·015	..	0·45	..	..	0·08	..	..	..	..	..	..	..
M 798	Oteroa ..	Sandy loam	5·8	18·9	0·43	0·038	0·013	Acid ..	0·23	0·05	0·06	0·12	Good ..	Excellent	19·0	51·0	7·0	5·2	10·0

Table 6.

Soils fully analysed.

——	L1121.	L1122.	L1123.
Organic matter and combined water	18·89	16·15	12·90
Silica (SiO_2)	54·81	62·39	64·02
Phosphoric anhydride (P_2O_5)	0·19	0·10	0·09
Calcium-oxide (CaO)	0·25	0·24	0·19
Magnesium-oxide (MgO)	0·15	0·09	0·09
Potassium-oxide (K_2O)	1·42	1·55	1·50
Sodium-oxide (Na_2O)	2·88	3·01	3·52
Manganese-oxide (Mn_3O_4)	0·60	0·42	0·38
Iron and aluminium oxides	20·81	16·05	17·31
	100·00	100·00	100·00

Note.—Analyses made on the samples dried at 100° C. No. L1121 is from open fern country; Nos. L1122 and L1123 are from affected forest country which has been cleared.

References.

Ross, D. 4th Annual Report, Department of Agriculture, 1896, p. 3.

Park, A., M.R.C.V.S. 5th Annual Report, Department of Agriculture, 1897, p. 68.

Gilruth, J. A., M.R.C.V.S. 6th Annual Report, Department of Agriculture, 1898, p. 70.

Park, A., M.R.C.V.S. 6th Annual Report, Department of Agriculture, 1898, p. 88.

Gilruth, J. A., M.R.C.V.S. 8th Annual Report, Department of Agriculture, 1900, p. 186.

——— 9th Annual Report, Department of Agriculture, 1901, p. 66.

Aston, B. C. 14th Annual Report, Department of Agriculture, 1906, p. 106.

Reakes, C. J., D.Sc. 18th Annual Report, Department of Agriculture, 1910, p. 33.

Department of Agriculture Journal, vol. 1, No. 6, p. 457, 15th November. 1910.

Aston, B. C. Department of Agriculture Journal, vol. 3, No. 5, p. 394, 15th November, 1911.

Art. XXXI.—*Note on the Composition of Nitric Acid.*

By H. T. M. Fathers.

Communicated by Professor Easterfield.

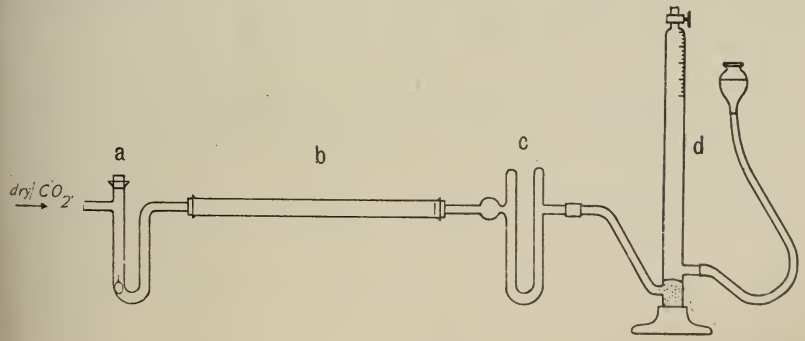
[*Read before the Wellington Philosophical Society, 4th October, 1911.*]

Though the composition and molecular weight of nitric acid are known to be represented by the formula HNO_3, I have been unable to find in any text-book a method of showing to a class that the substance really has the formula assigned to it. I have therefore worked out the details of a comparatively simple method whereby the demonstration may without difficulty be carried out.

1. Strong nitric acid is prepared by distilling a mixture of sodium-nitrate with an excess of 98 per cent. sulphuric acid at as low a temperature as possible, and the resulting acid is further dehydrated by distilling at about 20 mm. pressure (vacuum of the water-ejector pump) with three times its volume of strong sulphuric acid, and condensation of the acid-vapours by means of a good freezing-mixture. Diffusion of the aqueous vapour from the pump into the distillate is prevented by means of a tube containing pumice moistened with sulphuric acid. An acid prepared in this way will be found to be practically colourless, and to have a specific gravity and titration value corresponding to over 99 per cent. of pure nitric acid.

2. As soon as the acid is prepared a number of thin-walled glass bulbs, each capable of holding about 0·2 grams of acid, and blown on capillary stems about 3 cm. in length, are filled with the acid by placing the bulbs with the open end of the stem downwards in a beaker containing the acid and placing the beaker in a desiccator, which is then evacuated with the aid of the filter pump. Upon readmitting the air the bulbs will be found to be completely filled with acid, except for the presence of a very minute air-bubble. The ends of the capillaries are now sealed over a small flame, and the weight of the contained acid ascertained.

3. The apparatus in which the analysis of the acid is actually carried out is as follows :—



a is a U tube in which one of the bulbs containing a weighed quantity of nitric acid is placed. *b* is a short and narrow piece of combustion tubing containing a 10 cm. spiral of copper gauze which has been heated to redness

in situ in a current of air and subsequently reduced and allowed to cool in a stream of dry hydrogen; after this treatment the hydrogen has been displaced by dry air, and the tube and its contents weighed. *c* is a weighed calcium-chloride tube. *d* is a Schiff's nitrometer containing strong potash, with a mercury trap below.

4. The tubes *a*, *b*, *c*, and *d* having been arranged in position as shown, the air is displaced from the apparatus by a current of dry carbon-dioxide, conveniently prepared by heating sodium-bicarbonate in a test-tube and passing the gas over pumice moistened with sulphuric acid. When all the air is displaced the copper in *b* is heated to redness by a group of three or four Bunsen burners, the current of gas being at the same time slackened. The U tube *a* is now surrounded with hot water, which causes the contained bulb to burst, owing to the high coefficient of expansion of the nitric acid. The stream of carbon-dioxide carries the vapour of nitric acid over the red-hot copper, where it is decomposed according to the equation—

$$2HNO_3 + 5Cu = 5CuO + H_2O + N_2.$$

When no further increase in the volume of gas in *d* is observed, the nitrometer is disconnected and the rest of the apparatus allowed to cool in the current of carbon-dioxide. The carbon-dioxide is then displaced from *b* and *c* by a stream of dry air, and the increase in the weight of these tubes taken. The composition is then at once arrived at, for

Hydrogen = $\frac{1}{9}$ of the increase in weight of *c*.
Oxygen = $\frac{8}{9}$ of the increase in weight of *c* + the increase in weight of *b*.
Nitrogen = Number of c.c. of gas in *d* (corrected) × 0·00125 gm.

The ratio of the number of atoms is then obtained in the usual way by dividing the weight of each of the elements by the atomic weight of the same element respectively. Two experiments carried out on separate preparations of nitric acid by the above method gave—

(1) H : N : O = 1·02 : 1·00 : 2·92,
(2) = 1·00 : 1·00 : 2·97,

which are sufficiently near to the required ratio 1 : 1 : 3. The time taken from the commencement of passing the carbon-dioxide to the disconnecting of the nitrometer need not exceed half an hour, so that with a little foresight the analysis can be conveniently carried out in a lecture of an hour's duration.

Since the density of the vapour of nitric acid diluted with air has been shown to correspond approximately to that required for the formula HNO_3,* all the facts required by the student in the establishment of the formula are thus available.

* Playfair and Wanklyn, "Journal of the Chemical Society," vol. 15, p. 142.

Art. XXXII.—*The Interaction of Iron with the Higher Fatty Acids.*

By Thomas H. Easterfield and Clara Millicent Taylor, M.A. (New Zealand Government Research Scholar).

[*Read before the Wellington Philosophical Society, 9th August, 1911.*]

Introduction.

In a former paper* it was shown that under the action of metallic iron abietic acid is rapidly deprived of its carboxyl group with production of a hydrocarbon. It is well known that the higher fatty acids under conditions which should lead to deprivation of a carboxyl group yield ketones more easily than hydrocarbons, according to the equation

$$2X \cdot CO_2H = X_2CO + CO_2 + H_2O.$$

It therefore seemed probable that heating the higher fatty acids with iron filings would be a simple method for obtaining ketones in good yield.

Upon heating stearic acid with cast-iron turnings to a temperature of 360–365° C. it was found that over 80 per cent. of the acid was converted to stearone. As the usual method of preparing the ketone of stearic acid only gives about 50 per cent. of the theoretical yield, the advantage of the new process is obvious. Another and equally important point is that the quantity of acid which can be treated in one operation is almost unlimited. In the ordinary process of distilling calcium or barium stearate with slaked lime under diminished pressure from a combustion-tube the quantity of ketone prepared in each operation is necessarily small.

The method was also found to give good yields of ketone with lauric, palmitic, cerotic, montanic, and melissic acids, so that it may be regarded as a general method for the preparation of the ketones of the saturated fatty acids with from 12 to 30 atoms of carbon in the molecule. With acetic, butyric, phenyl-acetic, suberic, and sebacic acids no satisfactory results were obtained.

The ketones of the higher unsaturated fatty acids have not hitherto been prepared, but the "iron" method allows these compounds to be obtained without difficulty in the oleic series. In the linoleic series no experiments have been made, owing to the difficulty of obtaining the acids in a state of purity. During the progress of these experiments it was pointed out by Mailhe† that the vapours of the fatty acids from acetic to stearic acid yield ketones if passed over gently heated "reduced" metals, including iron, copper, nickel, cadmium, and lead. There is, however, an extraordinary difference between the catalytic action of the "reduced" metals (which are in general pyrophoric) and the same metals in the state of powder. (Compare, for example, the inertness of ordinary platinum with the intense catalytic action of platinum-black). Sabatier has, indeed, recently drawn attention‡ to the fact that "reduced" nickel exhibits quite different catalytic effects upon mixtures of hydrogen and acetylene, according to the conditions under which the reduction has been carried out.

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* Easterfield and Bagley, Trans. N.Z. Inst., vol. 35 (1902), p. 480.

† Bulletin de la Soc. chimique de Paris, 1909, p. 616.

‡ Berichte d. deutschen chem. Gesellschaft, 1911, p. 1996

Experimental.

1. *Preparation of Stearone.* — Pure stearic acid is heated with one-tenth of its weight of powdered cast-iron turnings to a temperature of 280° C. The temperature is then slowly raised to 360°, and maintained between 360° and 370° until evolution of carbon-dioxide almost ceases—usually about two hours. The product is freed from iron by means of hydrochloric or sulphuric acid, and from stearic acid by aqueous alkali. The ketone is twice crystallized from light petroleum with the addition of animal charcoal, and is then pure. The yield is 80–85 per cent. of that required by theory. The melting-point was found to be 88°, as stated by Krafft. An analysis gave—

Found.	Calculated.
C = 82·71	83·00
H = 14·01	13·87

2. *Preparation of Dihepta-decyl Carbinol.* — 1 gram of stearone was dissolved in 200 c.c. of amyl alcohol, and reduced by the slow addition of 8 grams of sodium to the boiling solution. The secondary alcohol crystallized out on cooling, and after several recrystallizations melted constantly at 89·5°.

Found.	Calculated.
C = 82·31	82·66
H = 14·03	14·19

The carbinol yielded an acetic ester melting at 61° (not sharply) and giving on analysis—

Found.	Calculated.
C = 80·80	80·73
H = 13·51	13·46

3. *Preparation of Oleone.* — 5 grams of pure oleic acid prepared from olive-oil, and melting at 14° C., was rapidly heated with one-tenth of its weight of cast-iron powder to 240°, and then more slowly to 340° and maintained at this temperature for two hours. The product was treated first with acid, then with alkali, afterwards crystallized from alcohol, and finally from acetic acid, until the melting-point was constant at 59–60°. The yield was 10 per cent. of the weight of the oleic acid taken.

The same yield of oleone of the same melting-point was obtained in an experiment in which carefully rectified oleic acid prepared from commercial olein was employed.

A smaller yield of oleone of the same melting-point was obtained by distilling pure barium oleate in a partial vacuum to a temperature which finally reached 450°. The distillate was rectified under reduced pressure, and the portion boiling at 280–330° at 5–10 mm. pressure deposited oleone on cooling. After several crystallizations the substance melted at 59°. The yield was only 2 per cent. of the theoretical amount. Analysis 1 was carried out on oleone obtained by the iron method, analysis 2 with oleone from barium oleate :—

1.	2.	Calculated.
C = 83·5	83·40	83·62
H = 13·6	13·10	13·14

The molecular weight by the ebullioscopic method in alcoholic solution gave—

M = 492 and 508. Calculated = 502.

Bromine absorption in twelve hours = 62·1. Calculated for 4 atoms, bromine = 63·8

4. *Isolation of Oleone from Commercial Olein.*—P. W. Robertson* showed that stearone is present in the last runnings from the iron stearine stills, and it appeared probable that oleone would also be present in the olein pressed from commercial stearine. This was found to be the case. Commercial olein was freed from solid matter by filtering at 10–12° and then submitted to fractional distillation at 40 mm. pressure, an efficient dephlegmating column being employed. From that portion which did not distil below a temperature of 300° solid matter was separated by dissolving in alcohol and adding a faint excess of alkali. The solid matter was proved by its melting-point (59°) and microscopic appearance to be oleone, which, though easily soluble in an alcoholic solution of oleic acid, is very sparingly soluble in an alcoholic solution of sodium oleate.

5. *Oleone Oxime.* — This compound is easily soluble in alcohol, and melts at 31°.

Found.	Calculated.
N = 2·73	2·70

6. *Reduction of Oleone by Hydriodic Acid.* — When oleone is treated with phosphorus pentachloride and subsequently reduced by hydriodic acid and phosphorus at 240° n.-pentatriacontane ($C_{35}H_{72}$) results. The substance melted at 72–73° (Krafft gives 74°).

Found.	Calculated.
C = 85·8	85·3
H = 14·8	14·6

7. *Preparation of Elaidone and Brassidone.* — These ketones were prepared from elaidic and brassidic acids, under conditions similar to those described for the preparation of oleone from oleic acid, with the aid of metallic iron. The yield of elaidone was 15 per cent., that of brassidone 50 per cent., of the theoretical quantity.

Elaidone melts at 70°, its oxime at 32°.

Analysis of elaidone :—

Found.	Calculated.
C = 83·33	83·62
H = 13·27	13·14

Analysis of elaidone oxime :—

Found.	Calculated.
N = 2·9	2·7

Brassidone melts at 80°, its oxime at 51°.

Brassidone :—

Found.	Calculated.
C = 83·49	84·03
H = 13·32	13·35

Brassidone oxime :—

Found.	Calculated.
N = 2·1	N = 2·2

* Trans. N.Z. Inst., vol. 37 (1905), p. 577.

Art. XXXIII.—*Nephelinite Rocks in New Zealand.*

By Professor P. Marshall, D.Sc., F.G.S., Otago University.

[*Read before the Otago Institute, 7th November, 1911.*]

It was not until 1891 that the mineral nepheline was recognized in any New Zealand rocks. In that year it was recorded by Ulrich (3) as occurring in a considerable number of rocks in the Dunedin volcanic region. Statements had previously been made by Park and Hill that some of the rocks on the south slopes of Ruapehu were phonolites. It has, however, since been found that these statements were erroneous, and so far as known all the rocks of Ruapehu are hypersthene-andesites.

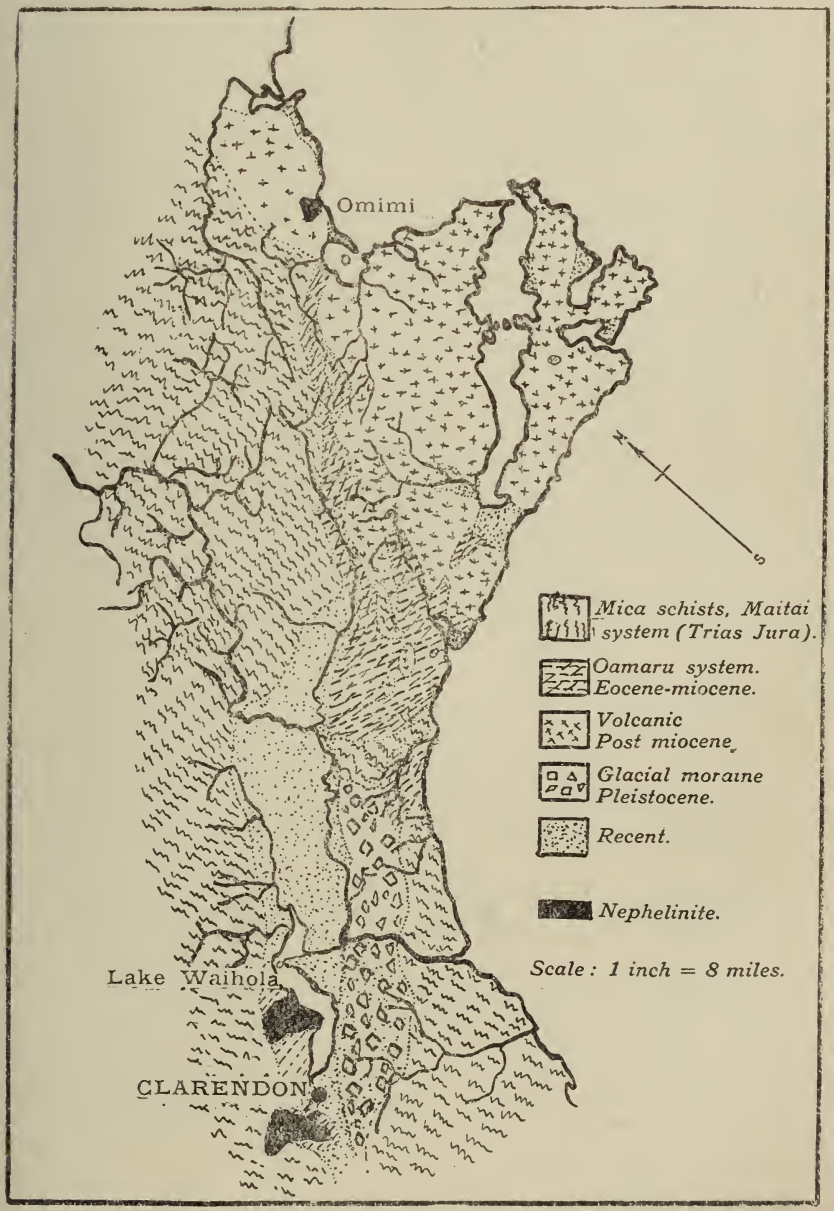
Though Ulrich described many types of nepheline-bearing rocks from the Dunedin district, he by no means exhausted the locality. Other types have since been described by Marshall, Boult, and Cotton; but there is still much room for research. Within the last few months Mr. J. P. Smith has added greatly to our knowledge in bringing to light the occurrence of interesting types of nephelinite, a rock that had not previously been recorded from this neighbourhood. Among the specimens deposited in the Otago Museum by Captain Hutton previous to 1879 was a rock with the label, "Dolerite, Lake Waihola." When this rock was examined microscopically it was at once seen to be a nephelinite. Search for an outcrop of it on the east side of the lake was, however, unsuccessful; and Andrew's account of the basalt on the south of the lake did not suggest that it occurred there. For some time no opportunity presented itself for an examination of the western shore of the lake. Recently, however, Mr. Smith was able to visit the western side, and he at once found a large outcrop of various types of this rock, which we were afterwards able to visit in company, through the courtesy of Mr. W. Adam, on whose property the outcrop is situated. Subsequently it was found that all the basaltoid rocks south of this lake are related to the nephelinitoid type. A distinct dyke of a rock of intermediate coarseness occurs at Clarendon, five miles south-west of Waihola.

Later Mr. Smith found a still more interesting type of nephelinite at Omimi, on the sea-coast, thirty-three miles north-east of the previous locality, but still in the same volcanic district. Here the actual limits of the doleritic form of the rock are not well defined, but, as at Waihola, the doleritic type is associated with a basaltoid development, which contains a large amount of allotriomorphic nepheline, and varies between nepheline-basanite and nepheline-basalt.

Another New Zealand locality for this type of nephelinite is in the Auckland Domain. Here there is no exposure of the rock in the solid, for all the specimens that have been obtained were derived from boulders ejected during the explosive eruptions of the volcano of which the cricket-ground now occupies the crater. This rock has been known for some time, but the only description hitherto published of it is in a general paper by Marshall (8). No analyses of any of these rocks have hitherto been published.

The occurrence of these rocks on the western side of the Waihola Lake is of special interest. Here the rock is extremely coarse over part of the outcrop (analysis A), and it has a structure that is apparently granitoid in hand-specimens. Apatite was the first mineral to

form in it. The prisms are of considerable size, as much as 1 mm. long and 0·18 mm. in diameter. The prisms are not numerous in the olivine or ilmenite, but are abundant in the younger constituents. Ilmenite in



GEOLOGICAL STRUCTURE OF PART OF EAST OTAGO.

grains of 1·5 mm. in diameter is rather frequent, and displays its usual structure. Olivine is fairly common in crystals as much as 6 mm. in diameter, and is somewhat serpentinized. The augite is a titaniferous

variety, with pronounced zonal and hour-glass structure, and with the usual pleochroism, and occasionally shows the steel-blue birefringence due to the high dispersion of the optic axes. A narrow margin is usually dark green. The mineral is completely idiomorphic. The nepheline is abundant, For the most part its crystallization was finished before that of the feldspar. It is largely altered to natrolite. The feldspar is much twinned on the albite and pericline laws, and has in many places the appearance of microline. The extinction-angle, however, proves it to be andesine. It was the last of the larger crystals to form. There is here and there a small quantity of groundmass. It consists of idiomorphic and often bent crystals of feldspar, probably andesine, allotriomorphic aegerine, nepheline converted into natrolite, and much apatite. Of these minerals, the nepheline was the last to form. In some of the finer-grained specimens the idiomorphism of the augite is less pronounced, and occasionally shows ophitic structure with the feldspar, which is then distinctly anterior in crystallization to the nepheline.

The basaltoid forms of the rock are well exemplified by a large dyke at Clarendon (analysis B). Here apatite is much less noticeable. The ilmenite and olivine are not more than 0·25 mm. in diameter. The augite is in moderate to small crystals, sinking to the dimensions of microlites, but always idiomorphic. Feldspar is not abundant, and is always in the form of microlites. Nepheline is quite abundant, and is in the form of allotriomorphic plates enclosing numerous crystals of olivine, augite, and ilmenite. Lava-flows that cover a considerable area of the country to the west of the dyke are also somewhat similar, but are of much finer grain (analysis C). The irregular plates of nepheline are in these rocks extremely small and hard to distinguish except by microchemical methods. This type of rock has previously been described by Andrew, who, however, failed to distinguish the nepheline, though he recognized that much of the rock was soluble in dilute HCl.

The type from Omimi is particularly interesting from the point of view of structure (analysis D). The apatite and ilmenite have the same features as before. The olivine, however, is in extremely small needles, sometimes 1 cm. long, but only 0·08 mm. wide. The direction of neighbouring crystals is in remarkably parallel lines in longitudinal as well as transverse section. They are similarly oriented over a considerable area. The phenocrysts of augite have pleochroism, zonal and hour-glass structure, as in the Waihola type. A similar appearance of lattice structure in the feldspar is also very noticeable. The nepheline is wanting in crystallographic boundaries, and is usually intergrown in complete micrographic fashion with augite. In some instances at least this augite is in optical continuity with the large crystals. This micrographic intergrowth is sometimes found in the groundmass in an extremely minute scale, and constitutes its dominant feature. The augite is sometimes slightly green in its smaller members. There are minute crystals of feldspar and apatite crystals in the groundmass. The intergrowth is of the same nature as that found in the Lobauer Berg type, but is much more complete, and is shown on a finer scale than in the German type.

As at Waihola, the rock is associated with basaltoid types, the exact distribution of which and their relation to the coarser type of rock has not yet been fully made out by Mr. Smith. Here, however, there appears to be a complete series through types with large allotriomorphic nepheline plates to types of a dense nature in which the nepheline is extremely hard to identify.

The Auckland type is somewhat similar to that of Omimi (analysis D). In most specimens the large augites have an ophitic structure. The olivine crystals, again, have a great length, 1·5 cm. by 0·46 mm., and again the direction of elongation is that of the axis *a*. The intergrowth of augite and nepheline is very complete, but is not carried to the extent of excessive fineness that is found in the Omimi type. The groundmass is rather more plentiful, and contains aegerine, apatite, and feldspar.

This rock is associated with basaltoid lavas which contain very little nepheline. The numerous volcanic cones near Auckland are formed of this dense type of basanite. The Auckland rocks have been mentioned previously (Marshall, 8).

Chemically, as would be expected, all the rocks mentioned are closely related, as is clearly shows by the following analyses :—

——	A.	B.	C.	D.	E.	F.
SiO_2	36·00	41·04	42·19	45·30	46·60	43·60
TiO_2	2·50	2·37	0·87	0·71	1·76	1·37
Al_2O_3	14·51	11·78	18·00	16·44	16·79	9·87
Fe_2O_3	7·19	6·86	7·73	1·82	3·87	7·43
FeO	10·28	9·52	8·67	8·82	7·58	5·40
CaO	12·95	10·50	9·27	7·85	7·85	14·26
MgO	4·02	5·38	7·06	2·73	2·88	7·18
K_2O	3·04	2·38	1·05	4·05	3·31	3·81
Na_2O	3·61	4·36	3·15	8·60	5·18	1·74
P_2O_5	1·56	1·23	..	1·68	1·76	1·85
Loss on ignition ..	4·40	4·00	1·35	2·96	3·04	1·01
Total	100·08	99·42	99·34	100·96	100·62	100·22

A. Coarse nephelinite, Lake Waihola.

B. Fine nephelinite, Clarendon.

C. Finest type of nephelinite, Clarendon. Andrew, Trans. N.Z. Inst., vol. 38 (1906), p. 461.

D. Nephelinite with micrographic structure, Omimi.

E. Nephelinite with micrographic structure, Auckland.

F. Nephelinite, Regatta Point, Tasmania. Paul, Tscher. Mitt., bd. 25 (1906), p. 301.

LITERATURE.

1. Hutton, F. W. "Geology of Otago," p. 56. Dunedin, 1875.

2. Hutton, F. W. "The Eruptive Rocks of New Zealand." Proc. Roy. Soc. N.S.W., 1889, p. 134.

3. Ulrich, G. H. F. "On the Occurrence of Nepheline-bearing Rocks in New Zealand." Trans. Aust. Ass. Adv. Sci., vol. 11 (1907), p. 127.

4. Andrew, A. R. "On the Geology of the Clarendon Phosphate-deposits, Otago, New Zealand." Trans. N.Z. Inst., vol. 38 (1906), p. 461.

5. Marshall, P. "The Geology of Dunedin, New Zealand." Quart. Jour. Geol. Soc., vol. 62 (1906), p. 381.

6. Paul, F. P. "Beitrage zur petrographischen Kenntniss einiger Foyaitisch theralitischer Gesteine aus Tasmania." Tscher. Min. Pet. Mitt., bd. 25, heft 4 (1906), p. 301.

7. Marshall, P. "Trachydolerites near Dunedin." Trans. Aust. Ass. Adv. Sci., vol. 10 (1904), p. 183.

8. Marshall, P. "Distribution of the Igneous Rocks of New Zealand." Trans. Aust. Ass. Adv. Sci., vol. 11 (1907), p. 366.

Art. XXXIV.—*The Discovery and Extent of Former Glaciation in the Tararua Ranges, North Island, New Zealand.*

By G. L. Adkin.

[*Read before the Wellington Philosophical Society, 6th September, 1911.*]

Plates XXII–XXIV.

The discovery of evidence of former glaciation in the Tararua Ranges was made by the writer in February, 1909, and two years later (March, 1911) further discoveries were made and the previous ones confirmed. The glaciated areas and the memorials of former frost-action so far discovered are situated on the highest ranges of the Tararuas—viz., on that part of the Dundas Range lying nearest the geographical centre of the mountain-system, and on the Mitre-Holdsworth Range. During the maximum phase of glaciation the heads of five river-valleys were filled with glacier-ice: (1) Park River,* the main tributary of the Waiohine-iti River, named after the well-known New Zealand glacialist; (2) the main source of the Waiohine-iti River; (3) Dorset Creek, a left-bank tributary of the Waiohine-iti River, named after a pioneer explorer of the Tararuas; (4) Bennington Creek, a tributary of the Waingawa River, rising in the south-west foot of the Mitre Peak, named after a companion of Edward Dorset; and (5) the Mangaterera River, another tributary of the Waingawa.

The phenomena resulting from the presence of glaciers now non-existent consist of—(1) U-shaped valleys; (2) glacial cirques; (3) rock basins; (4) glacial hanging valleys; (5) fluviatile hanging valleys.

In order to give a clear and correct impression of the extent and character of former glaciation in the Tararuas, the phenomena tabulated will first be dealt with seriatim, and then the topography of the Park Valley —the locality where these phenomena attained their maximum development—will be fully described.

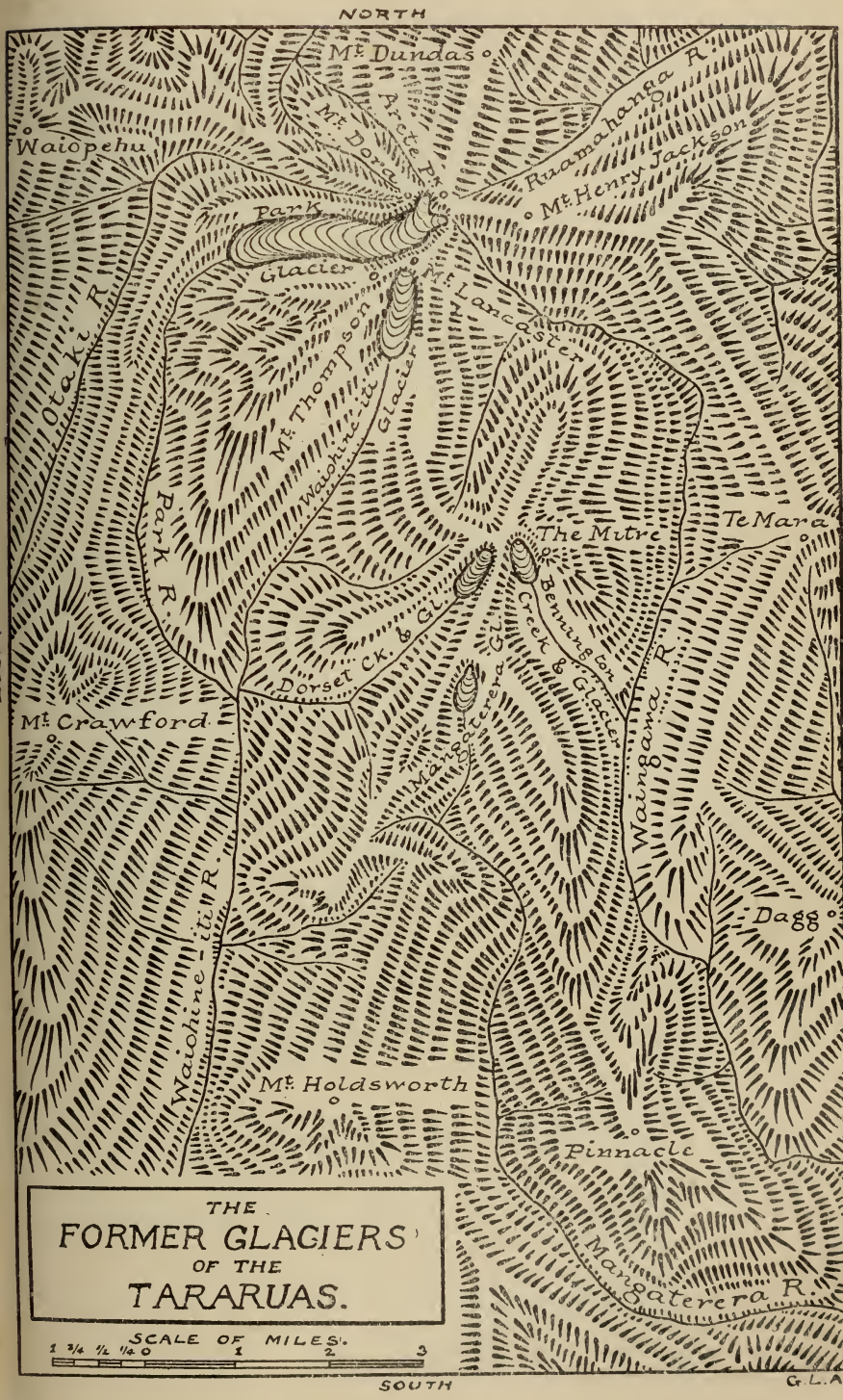
(1.) U-shaped Valleys.

U-shaped valleys furnish the principal evidence of the former presence of glacier-ice. So far as is at present known, they occur in five situations. The head of Park Valley is U-shaped for a distance of two miles; in the Waiohine-iti Valley the same feature extends for about one mile; in the valleys of Dorset and Bennington Creeks, for about half a mile each; and at the head of the Mangaterera Valley, about a quarter of a mile. The accumulation of scree-material, talus, and alluvium has to a certain extent obscured the U-shaped form and reduced the original steepness of the walls of these valleys, but even now their special character is unmistakable. Below their U-shaped heads the valleys contract to narrow gorges typical of fluviatile erosion.

* The river draining this valley has hitherto neither been named nor shown on any available map. On every available map the main source of the Otaki River is represented as draining the site of the upper portion of Park Valley.

Fig. 1.—General View of the Glaciated Part of Park Valley.

Fig. 2.—The Waiohine-iti Valley.
Showing the glaciated head and the V-shaped lower part. The Waiohine-iti pinnacles on left.


NORTH
Mt Dundas
Mt Dorothy
Arete Pk
Waiopehu
Ruamahanga R.
Mt Henry Jackson
Park
Glacier
Mt Lancaster
Otaki R.
Mt Thompson
Waiohine-itti Glacier
Park R.
The Mitre
Te Mara
Bennington Creek & Glacier
Dorset Ck. & Gl.
Mangaterera Gl.
Waingawa R.
WEST
EAST
Mt Crawford
Dagg
Waiohine-itti R.
Mt Holdsworth
Pinnacle
Mangaterera R.
THE
FORMER GLACIERS
OF THE
TARARUAS.
SCALE OF MILES.
1 3/4 1/2 1/4 0 1 2 3
SOUTH
G.L.A.

(2.) Glacial Cirques.

By far the finest example of a glacial cirque is to be found at the head of the U-shaped portion of Park Valley. This cirque is nearly half a mile across, and is bounded by mural precipices of imposing appearance. At the heads of the other U-shaped valleys the cirques are not so typically developed, the precipices being inconspicuous or absent.

(3.) Rock Basins.

There is every reason to believe that a rock basin exists in the floor of the cirque at the head of Park Valley. Since the disappearance of the ice it has been filled in with alluvium, and therefore its existence can only be demonstrated by evidence supplied by the general topography of the valley-floor. This evidence will be set forth below (p. 314).

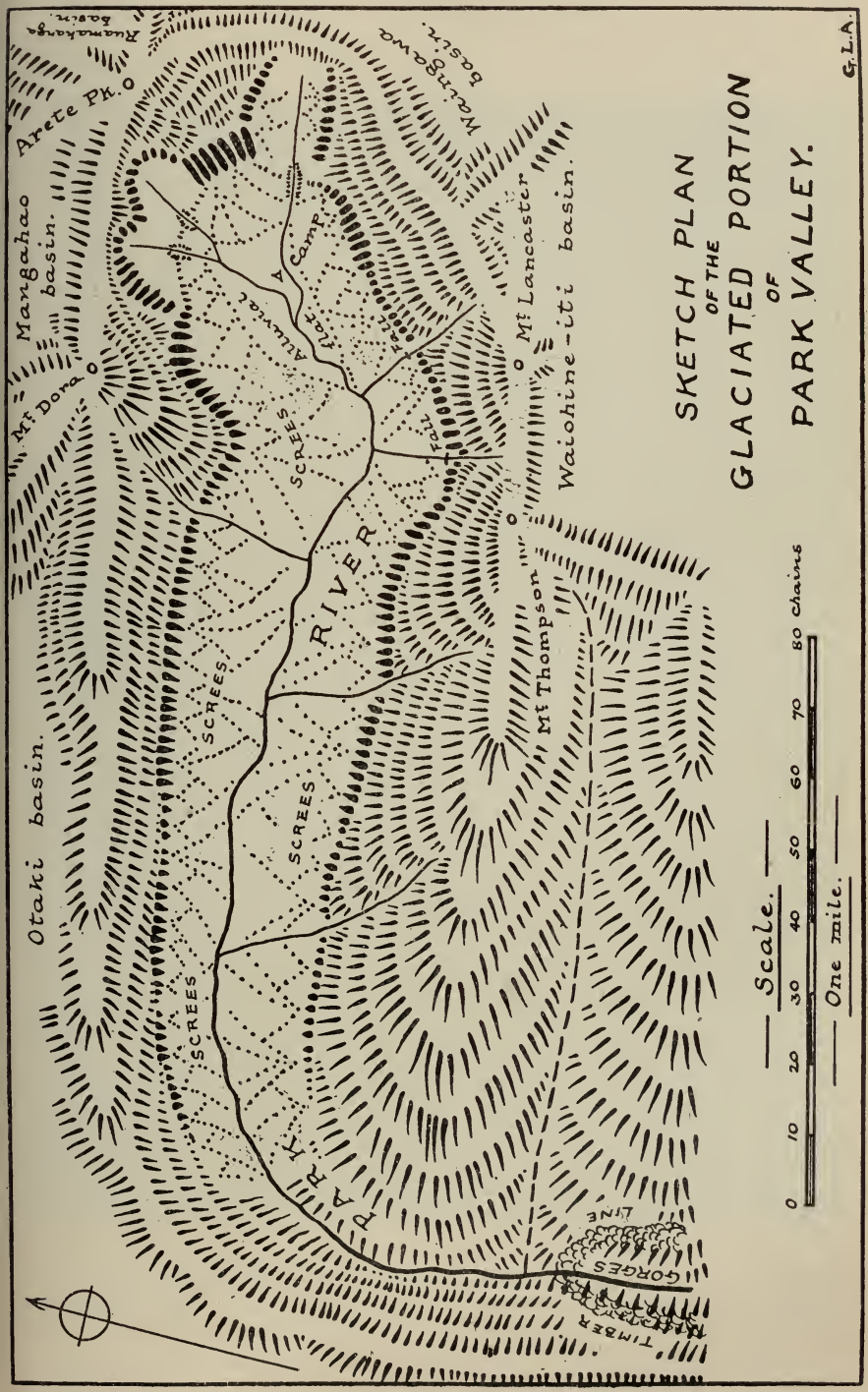
(4.) Glacial Hanging Valleys.

Three glacial hanging valleys open into the cirque at the head of Park Valley. They lie at heights of from 360 ft. to 510 ft. above the surface of the alluvial flat forming the present floor of the cirque. The largest has a length of about 15 chains, and the other two, which lie close together and are only divided by a low rocky ridge, are about 6 chains and 8 chains in length respectively. The lips of all three glacial hanging valleys have been cut by the streams that have drained the latter since the disappearance of the ice.

The floors of the glacial hanging valleys of Park Valley, and particularly that of the largest—and the evidence is therefore the more conclusive—show some signs of downward curving at the points where these valleys terminate and open into the main cirque. For this reason it is clear that the ice in the U-shaped hanging valleys must have descended to the head of the main glacier as icefalls; the upper surface of the ice in the main cirque—*i.e.*, the head of the trunk glacier—must therefore have stood somewhat below the level of the floors of the U-shaped hanging valleys, and probably attained a thickness of 500 ft. If the surface of the ice forming the head of the trunk glacier had stood above the level of, or even on a level with, the floors of the U-shaped hanging valleys, the terminal downward curving of their floors would have been absent, and the tributary glaciers would have joined the main one at grade. This they may have done during the maximum phase of glaciation, the icefalls and the wearing of the lips of the glacial hanging valleys by them being referable to a later date.

Glacial (U-shaped) hanging valleys occur at the heads of some of the other glaciated valleys also. There is a tiny one at the head of the valley of Bennington Creek. The cleft cut in its lip is in its incipient stages, so that small waterfalls still descend into the main valley. The precipices of the Mitre Peak surmount the north-east side of this hanging valley, and its head lies in the side of the main watershed of the Mitre-Holdsworth Range.

Another small glacial hanging valley is situated at the head of the glaciated portion of the Mangaterera Valley. Its lip also has been cut by the small stream which now drains it.


SKETCH PLAN
OF THE
GLACIATED PORTION
OF
PARK VALLEY.
G.L.A.
Otaki basin.
Mt Dora
Mangahao basin.
Arete Pk.
Waiohine-iti basin.
Mt Lancaster
Mt Thompson
RIVER
PARK
SCREES
Alluvial Flat
Camp
TIMBER LINE
GORGES
Scale.
One mile.
0 10 20 30 40 50 60 70 80 Chains

(5.) Fluviatile Hanging Valleys.

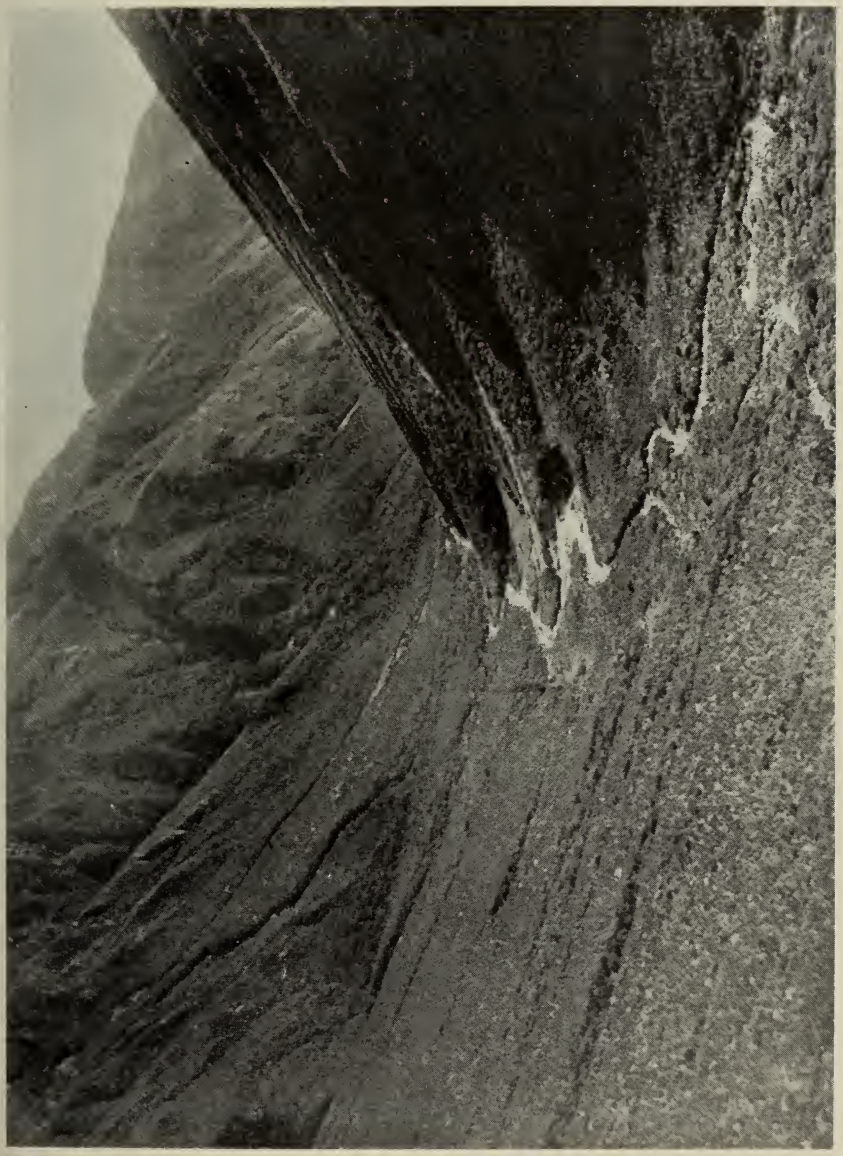
Hanging valleys having the typical V-shaped cross-section of stream erosion, and which owe their present state as such to the former presence of a glacier, are found in Park Valley only. The best examples are situated on the left wall of the valley, about three-quarters of a mile below the main cirque. The height of the falls which descend from their lower ends into the main valley is now greatly reduced by the infilling of the latter with scree-material. In the glaciated part of Park Valley the fluviatile hanging valleys are the sole remaining relics of its pre-glacial form—a form due entirely to fluviatile erosion. Prior to the glacial period the portion of Park Valley referred to was very much narrower, and also rather less deeply excavated than it is at the present time. From the ridges forming the watersheds on either side of the valley steep lateral spurs ran down to the valley-bottom, and the intervening gullies were in topographic adjustment with the trunk valley.

With the advent of the ice the pre-glacial topography of the upper portion of Park Valley was modified in two ways—the valley was both deepened and widened. The deepening was relatively greater in some parts of the valley than in others; in the main cirque the valley was over-deepened and the gradient of its floor reversed. Throughout the glaciated part of the valley the deepening was sufficient to remove all traces of the V-shaped contour of the pre-glacial trench, and to give the valley the typical flat bottom of glacier erosion. The widening of Park Valley by ice-action was of even greater extent and importance. In the achievement of this result the lateral spurs were deeply truncated, the intervening gullies betrunked and converted into hanging valleys, and the sides of the main valley cut back to such an extent as to give them a steep wall-like character. The present fluviatile hanging valleys were never ice-filled, but at the time of maximum refrigeration the tributary gullies nearer the head of the main valley were filled with ice, and were moulded thereby into their present U-shaped form. These U-shaped hanging valleys owe their present state as such more to the rapid erosion of the main cirque by the process known as "plucking" than to the lateral grinding which produced the fluviatile hanging valleys.

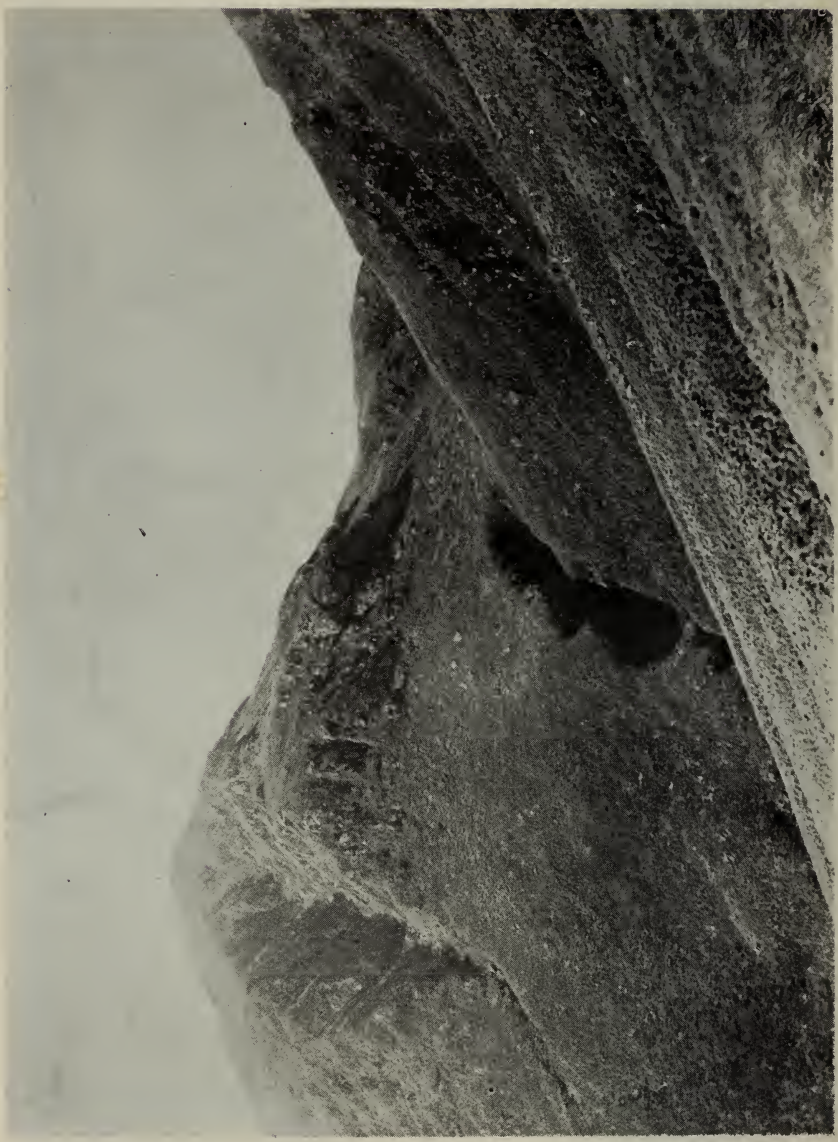
The Topography of Park Valley.

(See map, p. 311, and Plates XXII–XXIV.)

The topography of the upper portion of Park Valley is undoubtedly of glacial origin. The valley contains the most extensive and the best-preserved memorials of the erosion of glacier-ice, and therefore it has the distinction of being the former site of the largest of the extinct glaciers of the Tararua Ranges. The general trend of the glaciated part of the valley is west by south, but it is not straight; it runs in two curves—the upper bending southward, the lower northward. From the lower limits of glacial erosion the valley turns south-south-west and south-east to its junction with the Waiohine-iti River. This part of Park Valley is narrow and gorged. Lofty ridges form the boundaries of Park Valley, and the highest points of these—Mounts Thompson, Lancaster, and Dora, and Arete Peak—encircle its head, and in the past formed the gathering-ground of the perennial snowfields which fed the old glacier.

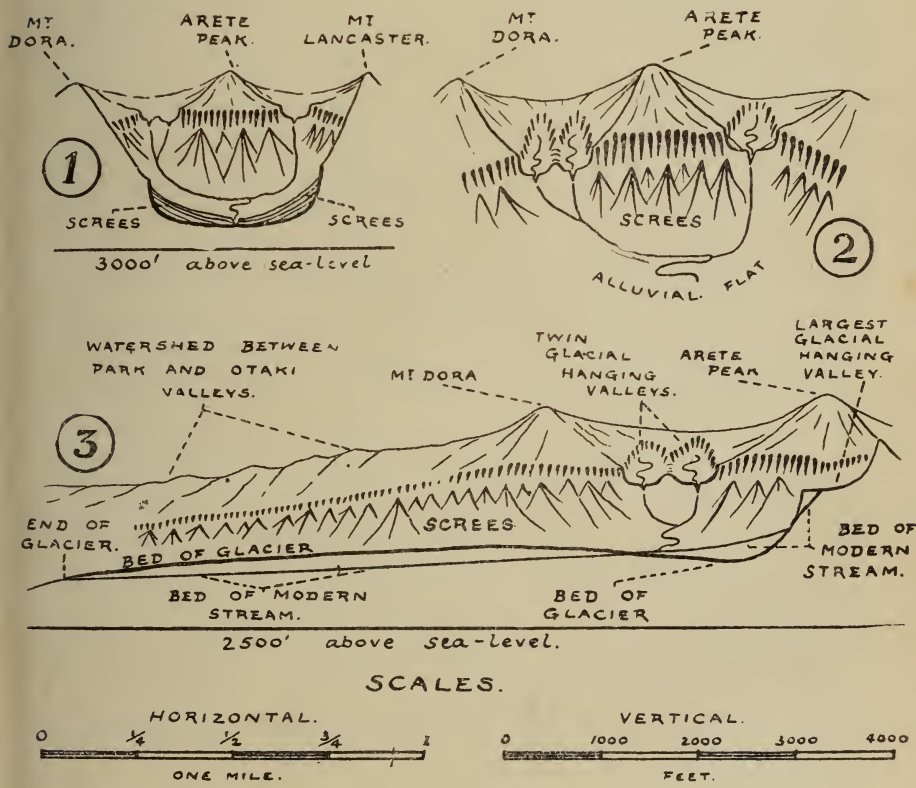


The Glaciated Head of Park Valley.
Showing alluvial flat in right foreground, and the screes on either hand.



The Largest Glacial Hanging Valley in Park Valley.
Showing the gorge cut in its lip by the modern drainage.

The main cirque at the head of the valley has a diameter of nearly half a mile. The precipices forming the bounding walls of the cirque attained a maximum height of 800 ft. above its floor. Below the cirque the valley is U-shaped for about two miles, the sheer lateral walls having a height of upwards of 400 ft. The U shape of the valley is less pronounced towards its lower end, and two miles below the cirque the latter narrows, gradually becomes V-shaped, and finally gorged. The continuity of the bounding precipices of the main cirque—which are best preserved on the south-west face of Arete Peak—is broken by the three U-shaped glacial hanging valleys. The largest of these lies on the south side of Arete Peak, and rises in a



Diagrammatic Sections of the Glaciated Portion of Park Valley.

(1.) Cross-section and diagram of main cirque. (2.) Enlarged view of cirque, showing glacial hanging valleys. (3.) Longitudinal section and diagram of left wall of valley.

rather poorly developed cirque. It has a length of about 15 chains. The other two lie between Arete Peak and Mount Dora, and rise in ill-defined cirques. They are twin valleys, being separated only by a low rounded ridge. Their length is about 6 chains and 8 chains respectively. A small narrow gorge has been cut in the lip of each of these glacial hanging valleys by the streams which now drain them.

The most striking feature of the main U-shaped valley is the high development of screes. These bury the precipitous walls to a height of from 250 ft. to 320 ft. above the valley-floor. Above the screes the lateral walls rise to a height of from 50 ft. to 100 ft. In the main cirque the precipices rise 290 ft. above the apexes of the screes. Throughout the greater part of its length the floor of the main valley is loaded with scree-material; the bases of the screes on the one wall meet the bases of those on the other, and the modern drainage-channel of the valley follows the line of contact. The screes are now not in the course of formation, being clothed with tussock-grass and subalpine scrub.

In the U-shaped section of its valley the Park River is actively engaged in altering the gradient of the valley-floor. In the main cirque it is an aggrading stream, and has there formed an alluvial flat several acres in extent. Below this flat the river flows in a narrow channel of gradually increasing depth. Near the lower limit of glaciation this channel is about 20 ft. deep, and the rock floor of the valley, upon which the screes rest, has been incised by the river to a depth varying from 10 ft. to 15 ft.

The infilling at the head of the valley, and the excavation below, clearly demonstrate that the valley was overdeepened* by the old glacier. After the disappearance of the ice the rock basin was probably the site of a small lake until it was filled in by the accumulation of alluvium.

Such criteria of former glaciation as moraines, *roche moutonnées*, and striated surfaces have not been found in Park Valley or in any of the other glaciated areas of the Tararuas. It is highly probable that some of the phenomena enumerated do exist, but in Park Valley, and in the other glaciated localities also, the present excessive accumulation of scree-material and alluvium precludes all possibility of their detection. The apparent absence of a terminal moraine may be accounted for by the small size of the glacier. It may be, however, that some of the angular debris resting on the valley-floor near the lower limit of glaciation is morainic material laid down during the slow but regular shrinking of the glacier during its final retreat. Another suggestion is that the great piles of boulders that encumber the narrow gorges situated immediately below the lower limits of glaciation in Park Valley are the re-sorted relics of a terminal moraine. According to this supposition, the terminal moraine of the old glacier was demolished and carried to lower levels since the disappearance of the ice by the periodic floods of the modern river. In this way the angular blocks forming part of the moraine were rounded and transformed into the boulders as they now exist. The boulders in the gorges referred to are very much larger and more numerous than any that lie within the glaciated upper portion of the valley.

The following altitudes in Park Valley were determined by the use of an aneroid set by the trig. on Mount Dundas: The saddle in the watershed of the Dundas Range at the head of the largest glacial hanging valley, 4,440 ft. above sea-level; the lip of the largest glacial hanging valley, 3,900 ft.; the lips of the twin glacial hanging valleys, 3,750 ft.; the centre of the alluvial flat in the floor of the main cirque, 3,380 ft.; the summits of the precipitous rock walls of the main U-shaped valley—left wall 3,800 ft., right wall 3,670 ft.; the lower limit of glaciation (*i.e.*, of the U-shaped part of the valley), 3,000 ft. above sea-level.

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* The glacial hanging valleys furnish additional evidence in favour of this conclusion.

General Conclusions.

The former glaciers of the Tararuas owed their existence to the then greater elevation of the country and to the more rigorous climatic conditions. At the present time the snow-line in the latitude of the Tararuas is about 8,000 ft. above sea-level. "The late Sir Julius von Haast, in his 'Geology of Canterbury and Westland,' estimates that during the glacial period the snow-line was 1,000 ft. lower than it is in New Zealand at the present time."* This estimate involves only a slight reduction of the annual temperature—a reduction presumably induced by cosmic or external causes or conditions—and appears to have been based on such, other factors being neglected. The evidence furnished by the configuration of the bed of Cook Strait (as shown by soundings) and by the physiography† of the lowlands at the western foot of the Tararuas indicates that the elevation of that part of the country has been reduced since the glacial period by at least 1,000 ft. Taking for granted that these estimates are correct, and that they represent the sum of the influences that lowered the snow-line, the snow-line in the Tararuas during the glacial period was, in relation to the present sea-level, 2,000 ft. lower than at the present time; in other words, the snow-line of the Tararuas formerly stood at a height of 6,000 ft. above the present sea-level. But it is evident from the known altitude and position of the extinct glaciers of the Tararuas that the lower limits of the permanent snowfields that fed them were at the most 4,000 ft., and perhaps only 3,500 ft., above the present sea-level. By taking as correct even the greater altitude—*i.e.*, 4,000 ft. above the present sea-level)—there is a discrepancy between it and the foregoing of 2,000 ft. This lack of agreement between the tentatively adopted and the actual altitude of the former snow-line may be removed by accepting one of the following amendments: that during the glacial period the snow-line was lowered (in each case with reference to the present sea-level)—(1) by more rigorous climatic conditions 3,000 ft., and by the greater elevation of the land 1,000 ft.; (2) by climatic conditions 1,000 ft., and by greater elevation 3,000 ft.; or (3) by climatic conditions 2,000 ft., and greater elevation also 2,000 ft. The last of these is probably nearest the truth, since the estimate that the snow-line was lowered by climatic influences only 1,000 ft., as pointed out by Mr. H. Hill (Trans. N.Z. Inst. vol. 27, p. 453), "is a very small one, representing, as it does, only a difference of about 3 degrees of temperature; and this certainly would not be sufficient to bring about a glacial climate in the South Island"; and, of course, still less so in the North Island, unless it can be shown that the latter stood at an enormously greater elevation in the early Pleistocene period.

The former glaciers of the Tararua Ranges give some indication of the extent and nature of the Pleistocene glaciation of the North Island: they show that in these respects it was limited, localized, and moderate. On comparison this view is found to be in harmony with the known extent

* H. Hill, "On the Hawke's Bay Pleistocene Beds and the Glacial Period," Trans. N.Z. Inst., vol. 27, 1895, p. 452.

† G. L. Adkin, "The Post-tertiary Geological History of the Ohau River, &c.," Trans. N.Z. Inst., vol. 43, 1911, p. 496.

of the Pleistocene glacial development in the South Island, a development which attained its maximum in the Wakatipu ice-cap in Otago, and its lesser phases in Canterbury and Nelson, where systems of gigantic glaciers of the alpine type came into existence. In the South Island the Pleistocene ice-masses decreased from south to north, and, though at that time they made an appearance in the North Island also, they were there of even less extent than might have been expected. The northernmost of the centres of glacier dispersion in the South Island appears to have been situated in the Hardy Range,* in Collingwood. In that locality the signs of former ice-action are abundant and well preserved; yet in the Tararuas—mountains only slightly inferior in altitude, and situated in practically the same latitude—the relics of the Pleistocene glaciers are meagre, and of a less definite character. It seems apparent, then, that conditions in the North Island were not so favourable for the development of glacial phenomena, and that no widespread glaciation was experienced.

These facts and inferences are quite at variance with the idea, expressed in a paper on "Some Evidences of Glaciation on the Shores of Cook Strait and Golden Bay,"† that the bed of Cook Strait during the Pleistocene elevation was occupied by a great glacier rising in the central highlands and flowing southward. In a succeeding paper by the same author it is stated that "a large portion of the Province of Wellington suffered intense glaciation in that [the Pleistocene] period."‡ In keeping with these views of the extent of former glaciation of the North Island, Professor Park expressed the opinion that evidence of ancient ice-action and the products of such would probably be found, among other places, "in the Wairarapa, near the Tararuas." The only interpretation which can be placed on this statement is that the author quoted believed that during the maximum phase of glaciation the Tararua Ranges supported glaciers which deployed upon the plains to the eastward. The evidence furnished by the Tararuas themselves is entirely opposed to such a suggestion. Until some more definite and conclusive evidence is adduced to support it, the doctrine of widespread glaciation in the Province of Wellington, and more particularly of the low-lying maritime areas of the same, is scarcely likely to gain general acceptance.

* See Bell, Webb, and Clark, Bulletin No. 3 (New Series), N.Z. Geol. Survey, pp. 31, 32, 1907.

† James Park, Trans. N.Z. Inst., vol. 42, 1910, p. 585.

‡ James Park, "The Great Ice Age of New Zealand," Trans. N.Z. Inst., vol. 42. 1910, p. 599.

Art. XXXV.—*The Geology of the Bluff, New Zealand.*

By L. J. Wild, M.A.

Communicated by Dr. P. Marshall.

[*Read before the Otago Institute, 3rd October, 1911.*]

1. Introduction and Description of the Topography of Area.

The generally even surface of the Southland Plain is broken on its coastal margin by a range of hills extending in a south-easterly direction from the mouth of the New River Estuary for a distance of seven miles, and terminating in Bluff Hill. The height varies much from point to point, but the outstanding feature is Bluff Hill, which attains an elevation of 860 ft.

Several geologists have visited the locality, or have examined specimens of rock from it, but the area has never been submitted to accurate and systematic geological examination.

Hutton,* in 1872, referred to the Bluff Hill in describing the geological structure of the Southland District. He also described the relative positions of some of the rocks found there, and such of their characters as can be detected in the field. In his "Geology of Otago," published in Dunedin in 1875, he repeated the conclusions he had come to.

In 1888 the general structure and physiographical nature of the district was described at some length by Park,† who also went into the evidence as to the age of the rocks; but the writer offered neither chemical nor microscopical descriptions of the various rock types.

At a later date Hutton‡ named and described sections of specimens of rock from Bluff Hill, but subsequently, with more material at hand, published additional notes,§ in which he expressed a change of opinion with regard to the nomenclature of some of them. It is rather unfortunate that the localities from which these specimens were obtained have not been recorded more definitely.

Hamilton‖ has also contributed to the literature on the subject, and the locality is also mentioned several times in "The Geology of Otago," by Hutton and Ulrich. The references in the latter publication will be discussed below.

Thomson¶ has recently published notes on some rocks which are "the result of a few hours' collection along the shore south and west from Bluff Harbour," and "from a small headland about half a mile round the coast to the south-west just beyond the mouth of the harbour." A glance at the map will show that "west" must be a misprint for "east."

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* Hutton, "Report on the Geology of Southland," Rep. N.Z. Geol. Surv., 1871–72, p. 89.

† Park, "On the Geology of Bluff Peninsula," Rep. N.Z. Geol. Surv., 1887–88, p. 72.

‡ Hutton, "Notes on the Eruptive Rocks of Bluff Peninsula," Trans. N.Z. Inst., vol. 23 (1891), p. 353.

§ Hutton, "Corrections of the Names of some New Zealand Rocks," Trans. N.Z. Inst., vol. 31 (1899), p. 484.

‖ Hamilton, "Notes on the Geology of the Bluff District," Trans. N.Z. Inst., vol. 19 (1887), p. 452.

¶ Thomson, J. A., "Notes on some Rocks from Parapara, Bluff Hill, and Waikawa," Trans. N.Z. Inst., vol. 42 (1910), p. 33.

The present paper will aim principally at an accurate description of the rocks that outcrop on the portion of the foreshore of Bluff Harbour lying between the wharves and Starling Point, together with the related rocks of Tewaewae Point, since this area exhibits in most striking manner the different rock types and their mutual arrangement.

The more detailed investigations herein described point to conclusions somewhat opposed to previously accepted ideas of the geology of the district.

Position.

The Bluff Range forms the backbone of a prominent peninsula of the south coast of the South Island of New Zealand, in latitude 46° 32′ S. and longitude 168° 23′ E. It extends for seven miles from north-west to south-east. It is united to the mainland by a narrow strip which projects to the east from the flank of the range at its north-western end,

Fig. 1.—Map of the Bluff District.

and separates the waters of Bluff Harbour on the south from the Mokomoko Inlet on the north. At its north-western extremity the range terminates in somewhat abrupt cliffs impinged on by the New River, the mouth of which has been driven east by the sands of the Riverton Beach, which are constantly travelling in this direction under the influence of the seas and currents caused by the prevailing westerly winds.

Origin of the Land-forms.

The range consists of a mass of igneous rock which was originally a deep-seated intrusion. Subsequent denudation acting more readily on the intruded than on the intrusive rocks has exposed the intrusive mass as a range of hills. The area of contact, which is fully described in the following pages, is thus a metamorphic aureole. The resulting metamorphic rocks outcrop in places as the base of the range on the north-east side, the most extensive outcrop being on the foreshore of the harbour from Henderson Street for a distance of 37 chains towards Starling

Point. A study of the rocks in this locality, together with those of Tewaewae Point, reveals the nature of the metamorphism, though the gap in the series occupied by the mouth of the harbour cannot be bridged in a manner absolutely satisfactory.

The origin of Bluff Harbour and Awarua Bay, as well as Waituna and other lagoons along the south coast between Bluff Hill and Fortrose, requires some explanation.

The sand and shingle driven by the prevailing current through Foveaux Strait came to rest at the lee side of Bluff Hill. Thence, after the manner commonly described, a sandbank extended outwards in a direction slightly north of east. At length it reached the headland of Waipapa and Slope Points, which attains a height of 800 ft., or slightly

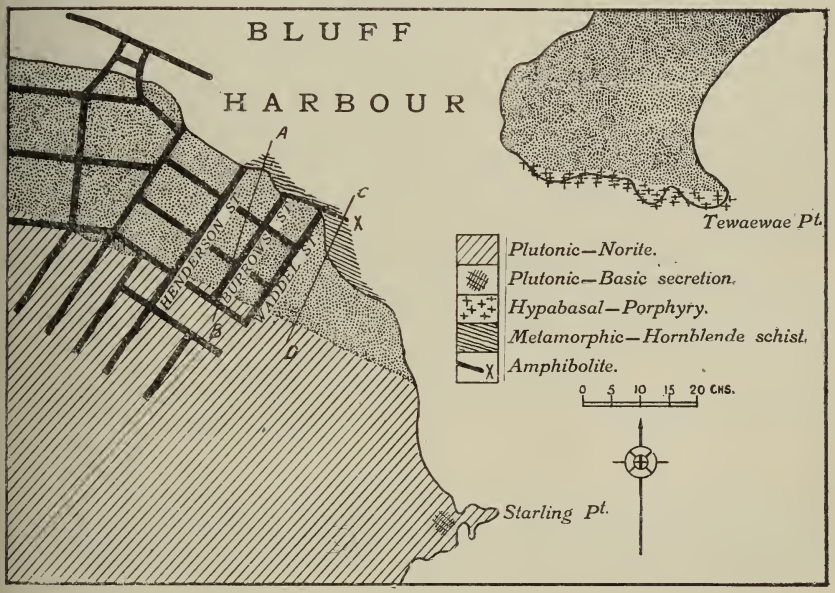

Fig. 2.—Geological Map of the Bluff.

more, some twenty miles to the east. Thus a considerable area of water was cut off and enclosed by the sandspit. As the sandbank received further additions it increased in height and mass most rapidly at its eastern end, where its onward progress was stopped by the headland already named. Finally, at its lowest end—that is, immediately adjacent to Bluff Hill—the waters broke over the barricade, and restored communication with the ocean. The channel was made across the intruded rocks, possibly along a groove commenced by the ancient rivers, and long since filled in with sand and alluvium. This channel, once begun, was rapidly deepened by the inrush and outflow of the tide, which in the middle of the channel travels at the present time at the rate of eight knots an hour, such is the size of the basin to be filled.

Subsequently this large lagoon was subdivided by lateral sandspits, and Waituna Lagoon was separated from Awarua Bay, and a separate outlet was formed.

II. Description of the Rock Types and their Geological Occurrence.

For the purpose of description the rocks of the Bluff district are conveniently divided into two main divisions, distinguished here as A and B. These divisions are—A, the igneous rocks; B, the metamorphic rocks.

Each of these divisions may be further divided into classes, the rocks of each class in the division being entirely distinct. The igneous rocks, Division A, consist of—I, igneous rocks of plutonic origin; II, igneous rocks of hypabyssal origin. The term "hypabyssal" is here used in the same sense as Harker* uses it, hypabyssal rocks corresponding in a general way, though not precisely, with the group "gangesteine" or "dyke-rocks" of Rosenbusch.

The metamorphic rocks, Division B, contain two classes, as follows: I, acid metamorphic rocks; II, basic metamorphic rocks.

An attempt will be made below to show that there is an intimate connection between the acid metamorphic rocks (Division B, Class I) and the igneous rocks of hypabyssal origin, the metamorphic rocks being derived from the hypabyssal ones. This is not the view taken by previous investigations—*e.g.*, Hutton and Park—but the present theory is the outcome of the examination of material that had not previously been brought under inspection. The point will be fully discussed in the course of this paper.

The relationship among some classes and the absence of relationship among others thus briefly mentioned makes it difficult to suggest any perfectly satisfactory scheme of classification.

Division A.—The Igneous Rocks.

Class I.—Igneous Rocks of Plutonic Origin.

1. Norite.

As has been stated above, igneous rock of plutonic origin forms the backbone of Bluff Peninsula. The mass is believed to be essentially one throughout as regards chemical and mineralogical composition. This Park† definitely states to be the case.

The present paper will deal with the rock as it is typified in Bluff Hill. There are numerous outcrops at the surface, as well as a continuous outcrop at sea-level along the south-east end and the south-west side of the range, except in the rare intervals occupied by sandy beaches. From specimens collected from different parts of the mass some thirty sections have been prepared and examined.

Hand-specimen (specific gravity, 2·68).—The rock varies somewhat in grain in different parts of the mass, though this variation is apparently not systematic. In some parts it tends towards a pegmatitic structure; sometimes a dense black rock of fine grain is found.

The typical rock is a rather coarse-grained type, speckled black and white. With a lens the black grains may be distinguished as pyroxene or hornblende, according to the characteristic cleavage. The white specks are feldspar.

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* Harker, A., "Petrology for Students," 4th ed. (1908), p. 108.

† Rep. N.Z. Geol. Surv., "The Geology of Bluff Peninsula." 1887, p. 89.

Under the Microscope.—Examination of thin sections shows the rock to be composed essentially of feldspar, augite, hypersthene, and hornblende, with magnetite as an accessory constituent. The feldspar, which on an average forms half the rock, occurs usually in plates, ranging in size up to 1·4 mm. long by 1 mm. broad. It also is found in irregular pieces enclosed ophitically by the ferro-magnesian minerals. It is a triclinic variety, showing both coarse and fine albite lamellation. The extinction-angle ranges up to 27°, this angle being the one recorded most frequently in sections as nearly perpendicular as possible to the albite lamellae parallel to the brachipinacoid.

According to the statistical method of Michel Lévy for determining the feldspars, this angle denotes labradorite. In some cases, however, an angle of 16° in found on each side of the trace of the twinning-plane. In such a basic rock this figure indicates andesine, and Thomson thinks this is the prevailing species, though he affirms that "probably more than one variety of feldspar is present." Undulose extinction and the bending of twin lamellae in a number of the crystals give evidence of considerable crushing.

Of the ferro-magnesian minerals hornblende is the most prominent. It frequently occurs as a fringe of varying breadth bordering the crystals and masses of pyroxene. In these cases it is a pale-green colour, and rather feebly pleochroic on the inner margin, but in the outer portion of the fringe it becomes more compact and denser in colour and pleochroism, changing from yellow-green to browny green.

Often, again, the hornblende occurs in masses apparently independent of the pyroxenes. Under these circumstances it is compact, brownish-green in colour, and strongly pleochroic. Thomson* mentions that "the cores of the hornblende crystals generally consist of a paler variety in optical continuity with the green exteriors, so that the former presence of pyroxene is suggested." This point will be further discussed (pp. 331–2).

Both monoclinic and orthorhombic pyroxenes are to be seen. Augite occurs in rounded grains and in irregularly shaped crystals. It is colourless and non-pleochroic, and, where fresh, shows brilliant polarization colours of the second order. But often it is cloudy, and shows signs of decomposition, which, no doubt, ultimately gives rise to the particles of chlorite recorded by Hutton† and Thomson.*

Diallage also occurs, though somewhat sparingly. It encloses minute tabular scales of a reddish-brown colour, arranged parallel to the basal plane, giving it the schiller structure, which distinguishes it from augite.

The orthorhombic pyroxene is hypersthene. In some cases it exhibits schiller structure like the diallage, but it may be distinguished from the latter mineral by its pleochroism and by the fact that it extinguishes straight. These characters also distinguish it from augite. The pleochroism showed a or $\breve{a}$ brownish red, b or $\bar{b}$ reddish yellow, c or $\dot{c}$ green, pale watery colours in each case. To determine definitely that the mineral was not enstatite, many sections were examined in convergent light to secure an optic axial interference figure, and thus find its optical character, but these attempts were unsuccessful. However, the pleo-

* Thomson, J. A., "Notes on some Rocks from Parapara, Bluff Hill, and Waikawa," Trans. N.Z. Inst., vol. 42 (1910), p. 33.

† Hutton, F. W., "Notes on the Eruptive Rocks of Bluff Peninsula," Trans. N.Z. Inst., vol. 23 (1891), p. 353.

chroism is usually accepted as sufficiently distinctive. After hornblende, hypersthene is the chief ferro-magnesian constituent in this rock. It occurs in rather elongated crystals, some of which show cross-fractures, and in smaller rounded grains.

Magnetite is fairly abundant, in irregular masses, moulded on the other minerals. Thomson* thinks the iron-ore is probably ilmenite. He gives no reason, however, for thinking it to be ilmenite rather than magnetite. Hamilton† noticed considerable disturbance of the magnetic needle while he was in this district, but, as ilmenite also affects the magnetic needle, Hamilton's observations do not point conclusively to magnetite, though they are certainly significant.

Order of Crystallization.—Observation of the form and arrangement of the minerals in this rock does not support the theory suggested by Rosenbusch as to the normal order of crystallization. According to his theory, magnetite should have been the first mineral to crystallize, and in sections there should be at least some well-shaped crystals idiomorphic towards the other constituents. Next in order the ferro-magnesian minerals should have separated out, forming crystals idiomorphic towards the feldspar, the last mineral to crystallize.

The actual sequence of events, however, seems to have been as follows: First a small amount of feldspar crystallized out, for crystals of this mineral are enclosed in both magnetite and hornblende; then the remaining feldspar and the ferro-magnesian minerals crystallized out, and sometimes the latter constituents show an approach to idiomorphism, while sometimes the opposite is the case; finally magnetite separated from the magma, and formed interstitially.

In accordance with recent theories of the dependence of structure on eutectic relations,‡ the explanation would be as follows: Feldspar was originally in excess, and an amount crystallized out sufficient to reduce the ratio of feldspar to ferro-magnesian minerals to a eutectic proportion. These minerals then crystallized together until a eutectic proportion between them and the magnetite was arrived at, when all crystallized together, but since a large percentage of the rock was already in a crystalline state the magetite had little chance of becoming idiomorphic.

The Origin of the Hornblende.—The Rev. H. Baron in conversation with Captain Hutton§ long ago expressed the opinion that all the hornblende in this rock is of secondary origin. This opinion receives support in the fact that very many of the pyroxene crystals are bordered by a rim of hornblende, which first appears as a narrow fringe, pale green in colour, and rather faintly pleochroic. This fringe increases in width at the expense of the pyroxene, and as it widens it increases in depth of colour and in intensity of pleochroism. Finally the pyroxene is entirely replaced by amphibole. The examination of a very few sections shows this change in all its stages. These observations show definitely that at least a large amount of the hornblende is secondary.

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* Thomson, J. A., "Notes on some Rocks from Parapara, Bluff Hill, and Waikawa," Trans. N.Z. Inst., vol. 42 (1910), p. 33.

† Hamilton, "Notes on the Geology of the Bluff District," Trans. N.Z. Inst., vol. 19 (1886), p. 452.

‡ Vogt, J. H. L., "Physikalische-chemische Gesetze der Kristallisation folge in Eruptivgesteine," Isch. min. u. petr. Mitt. 24, p. 437, 1905.

§ Hutton, F. W., "Corrections of the Names of some New Zealand Rocks," Trans. N.Z. Inst., vol. 31 (1899), p. 484.

The inference that all the hornblende in this rock is secondary is supported by descriptions of similar areas in various parts of the world. Such areas have been described by Irving* and by Williams† in America, by Phillips‡ in Cornwall, by Reusch§ in Norway, by Lehmann‖ in Saxony, by Becke¶ in Lower Austria, by Wadsworth** and by Hawes†† in America, and more recently by Harker‡‡ in the west of Scotland.

As regards the causes that produced the alteration of the pyroxene little is yet known. The experiments of Mitscherlich and Berthier (1824), Gustav Rose (1831), and Professors Fouge and Michel Lévy, of Paris, and the recent researches of Vogt, Joly, Cusack, Doelter, Brun, Day, Allen, and others have shown that augite appears to be the stable form at high temperatures and hornblende at low temperatures. From this it may be assumed that any condition tending to facilitate molecular readjustment at ordinary temperatures must necessarily tend to facilitate the change from augite to hornblende.

These considerations inclined Williams§§ to ascribe the uralitization of some rocks to the action of great pressure, such as might be exerted by the upheaval of mountains, and Lehmann‖ and Hatch¶¶ reached similar conclusions. Subsequently, however, Williams† decided that, though pressure may, and doubtless does in many instances, assist in the paramorphism of pyroxene in rocks, it cannot in all cases be regarded as even a necessary adjunct.

In the case of the plutonic mass of rock forming Bluff Hill the following points are put forward merely as suggestions.

The magma was intruded at sufficient depth to allow of the formation of a holocrystalline mass by slow cooling. At the temperature of the mass augite was formed. When ordinary temperature was reached the augite would tend to change to hornblende if conditions should change so as to induce unstable equilibrium in the crystals so far as the molecular forces were concerned. Such a change of conditions would possibly be brought about by either or all of the following :—

(1.) Diminution of pressure by denudation of the overlying rocks. This undoubtedly took place, but whether it would tend to induce molecular readjustment is a matter for speculation.

(2.) Movements of depression and elevation described above.

(3.) Lateral pressure due to the folding to which the whole country was submitted in late Palaeozoic or early Mesozoic times.

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* Irving, R. O., "Origin of the Hornblende of the Crystalline Rocks of the Northwestern States," Am. Journ. Sci., vol. 26 (1883), p. 32.

† Williams, G. H., "The Gabbros and Associated Hornblende Rocks occurring in the Neighbourhood of Baltimore, Md.," U.S. Geol. Surv., Bull. No. 28, 1886.

‡ Phillips, Quart. Journ. Geol. Soc., vol. 32 (1876), p. 155, and vol. 34 (1878), p. 471.

§ Reusch, "Die fossilienfuhrenden krystallinen Schiefer von Bergen in Norwegen," German translation by R. Baldauf, 1883, p. 35.

‖ Lehmann, "Untersuchungen über die Entstehung der altkrystallinischen Schiefergesteine," p. 190; Bonn, 1884.

¶ Becke, "Mineralogische und petrographische Mittheilungen," vol. 4, p. 357, 1882.

** Wadsworth, "Bulletin Museum Comparative Zoology of Harvard College, Cambridge," vol. 7, p. 46.

†† Hawes, G. W., Am. Journ. Sci. (3), vol. 12, p. 136.

‡‡ Harker, A., Mem. Geol. Surv., Tert. Ign. Rocks Skye (1904), p. 319.

§§ Williams, G. H., Am. Journ. Sci. (3), 28, p. 266 (1884).

¶¶ "Mineralogische und petrographische Mittheilungen," vol. 7, p. 83 (1885).

In this paper the name "norite" has been adopted in accordance with the views of Harker and Rosenbusch.

As has been shown above, the Bluff rock consists essentially of a soda-lime feldspar, a monoclinic pyroxene, and an orthorhombic pyroxene. Both kinds of pyroxene are changing to hornblende, and in the case of crystals, where the change is completed, it is impossible to say whether the hornblende is derived from orthorhombic or from monoclinic pyroxene. However, so far as may be judged from what remains, the orthorhombic variety is dominant, and the rock is therefore a norite rather than a gabbro.

Chemical Composition.—If the chemical composition be appealed to, as some authors demand, it also will be found to support the classification here suggested.

SiO_2	48·10
TiO_2	..
Al_2O_3	20·85
Fe_2O_3	4·85
FeO	10·55
MnO	Trace.
CaO	7·15
MgO	3·99
K_2O	0·63
Na_2O	2·73
H_2O and loss on ignition	1·00
Total	99·85

Specific gravity, 2·68

2. Basic Secretion.

At Starling Point the norite encloses a mass of a dark-coloured rather fine-grained rock. Specific gravity = 3·035.

The size of the mass cannot be made out definitely, as there is a coating of soil at this locality. The outcrop is small, being exposed in a cutting about half a chain in length and 6 ft. or 8 ft. deep. But, judging by the position of the outcrops of norite around it, the surface extent of the mass cannot be more than a chain in diameter. As has already been stated, the norite varies much in texture from point to point, and in some cases approaches to a material similar to that now under description. This led Hutton to describe several varieties of rock from the district.

Under the microscope the rock presents a similar assemblage of minerals to the norite, but there is a very noteworthy increase in the proportion of ferro-magnesian minerals. Hornblende forms more than half the rock, magnetite is abundant, there is a little pyroxene, and a basic plagioclase, sometimes containing needles of apatite, forms the rest. There is an approach to a rough gneissic structure.

Structure and Order of Crystallization.—The rock has a coarsely schistose or gneissic structure, and this tends to obscure the order of crystallization, so that it cannot be made out with any degree of accuracy. Hornblende seems to dominate, but the edges of its crystals are extremely ragged. In fact, no mineral can be said to be idiomorphic, and the

manner in which the crystals of the principal three constituents are intergrown suggests simultaneous crystallization. The fact that there is no sign of graphic structure, however, and the tendency towards gneissic structure that is observable suggest recrystallization.

Park,* in 1887, described this mass as an inclusion of the metamorphic rocks in the norite. But this explanation now seems improbable, as a glance at the following list of analyses will show. A and C are the results obtained above on an analysis of the hornblende schist and the norite respectively. They are repeated here for comparison with B, an analysis of a specimen of the mass under discussion.

	A.	B.	C.
SiO_2	61·00	44·40	48·10
Al_2O_3	13·66	20·55	20·85
Fe_2O_3	2·43	6·57	4·85
FeO	10·83	9·26	10·55
CaO	7·35	11·50	7·15
MgO	1·44	5·21	3·99
K_2O	0·52	0·19	0·63
Na_2O	1·90	1·14	2·73
Loss on ignition	1·20	1·00	1·00
Totals	100·33	99·82	99·85
Specific gravity	2·56	3·035	2·68

The analysis shows that the inclusion is more basic even than the norite, so that it cannot be considered merely as an included mass of hornblende schists. For the same reason it is not likely to be due to the complete absorption of a portion of the schist in the norite magma.

A more probable explanation of the occurrence of this mass depends on the theory of differentiation, to which much importance is attached by many modern geologists. Thus Harker† says, "We are left free to conjecture that the settling-down of crystals, which seems to be generally ineffective in a sill or laccolite, may give rise to very important differentiation in a large intercrustal magma-basin, cooling at an extremely slow rate. Various special features observable in igneous rocks are susceptible of interpretation on this hypothesis, and serve in a measure to support it. The dark basic secretions or 'clots' which occur sporadically in many granites and other rocks may be taken as an example. These consist in general of the same mineral as the normal rock, but are much enriched in the darker and denser minerals or in those of earlier crystallization. It seems reasonable to regard them as portions picked up from a lower stratum of the magma-reservoir, where crystals of these minerals accumulated by settling down in the magma."

This theory certainly seems to explain the case in point, where we have an inclusion which, compared with the norite, shows a decrease of 3·7 per cent. of silica, and a total increase of 6 per cent. in the oxides of the bases iron, calcium, and magnesium. Its specific gravity, also, is 3·035, compared with 2·68 in the case of the norite.

* Park, J., "Notes on the Geology of Bluff Peninsula," Rep. N.Z. Geol. Surv., 1887–88, p. 72.

† Harker, A., "The Natural History of Igneous Rocks," p. 322, 1909.

Class II.—Igneous Rocks of Hypabyssal Origin.

1. Porphyry.

The typical rock is found across the channel of the harbour, opposite Starling Point, where it forms a fringe bordering the tongue of sand which bears the name of Tawaewae Point, and which is really the north head of the harbour.

The outcrop extends below low-water mark, but above that line its width is only 15 or 20 yards. The rock is traversed by joints which divide it into more or less oblong blocks of a variety of sizes. One set of these joints strikes approximately north-west to south-east; the other set crosses at right angles. The dip varies from 0° to 30° N.E. The total length of the outcrop is about 16 chains.

Hand-specimen (specific gravity = 2·5).—The rock is dense, and when freshly broken is of a light-grey colour. The weathered surface, however, is of a dirty brownish-yellow colour, and from it project numerous crystals of feldspar.

Under the Microscope.—Thin sections show phenocrysts of feldspar in a groundmass consisting of feldspar, quartz, hornblende, and mica. Magnetite also occurs, partly in masses of irregular size and shape, and partly in small crystals.

The phenocrysts of feldspar vary considerably in size, some going up to as much as 2·4 mm. by 1·2 mm., but the average size is 0·9 mm. by 0·6 mm. They are chiefly orthoclase, and show twinning after the Carlsbad law in nearly every case. Less common are phenocrysts of a plagioclase variety. These show the albite twinning very poorly developed, and I have no section in which an absolutely satisfactory identification may be made. The available evidence, however, points to albite.

None of the phenocrysts are entirely fresh, while many bear in a marked degree the signs of decomposition, and all stages between the two extremes are represented. The first stage is a cloudiness which spreads irregularly over the crystal, and associated with it is the deposition of a very fine dark-coloured opaque dust. Then appear minute pale colourless microlites, which as they increase in size assume a pale-green colour, and are distinguishable as hornblende. As the microlites increase in size and number, larger and more definitely shaped crystals of magnetite appear. The needles of hornblende grow at the expense of the feldspar, for they penetrate through and through the crystals of this mineral, and also appear in great number round the edges of crystals, where they finally arrange themselves in aggregates. As mineral change becomes more and more complete small grains of quartz and flakes of brown mica appear. Finally we see a cloudy space, recognizable by its size and shape as the ghost of a feldspar, containing needles of hornblende, grains of magnetite, and quartz and flakes of biotite.

The groundmass is partly crystalline and partly glassy. The crystalline portion consists of grains of feldspar and of quartz, crystals of hornblende, and small flakes of brown mica. The grains of feldspar are rather rounded in shape, much decomposed, and many show undulose extinction. The decomposition is associated with the deposition of the fine dust above mentioned and with the formation of hornblende. Quartz is in rounded grains, ranging up to 0·08 mm. in diameter.

Chemical Composition.—It was found impossible to obtain an analysis of a true porphyry similar to that of the Tewaewae Point rock. Comparisons with rocks from American and European localities are given

below. B is a type mineralogically similar to the Bluff porphyry; C and D are analyses of typical porphyries, one from "Analyses of Rocks," U.S. Geol. Surv., the other from Rosenbusch.

	A.	B.	C.	D.
SiO_2	67·60	71·33	73·50	68·65
TiO_2	..	0·55	..	0·20
Al_2O_3	12·29	12·55	14·87	18·31
Fe_2O_3	3·15	3·75	0·95	0·56
FeO	4·88	0·85	0·42	0·08
MnO	..	0·04	0·03	Sp.
CaO	2·90	0·94	2·14	1·00
MgO	1·08	0·58	0·29	0·12
K_2O	2·16	4·20	3·56	4·74
Na_2O	5·67	4·52	3·46	4·85
Loss on ignition ..	0·15	0·42	0·90	0·83
Totals	99·88	99·73	100·12	99·35

Specific gravity, 2·5.

A. Porphyry, Tewaewae Point, Bluff.

B. Porphyry, Missouri. Composed principally of orthoclase and quartz, with some microline, plagioclase, and biotite, and minor accessory minerals. ("Analyses of Rocks," U.S. Geol. Surv., F. W. Clarke, 1904.)

C. Porphyry, Mount Zion. Contains orthoclase, plagioclase, quartz, biotite, apatite, magnetite, and zircon. (Anal., L. G. Eakins.)

D. Alkaligranitporphyr mit Einsprengl. von Orthoklas und Oligoklas; grundmasse wesentlich Quartz und Anorthoklas. (Rosenbusch, H., "Elemente der Gesteinslehre," 1901, p. 205.)

A study of these analyses shows that compared with typical porphyries the Bluff type is relatively rich in the oxides of the bases calcium, magnesium, and iron, and correspondingly poor in silica, while the proportion of alumina and alkalies is about normal. Further, it compares favourably with the analyses of the quartz-porphyrites except as regards the percentage of alumina. In other words, the rock is mineralogically a porphyry, but chemically it tends towards the porphyrites.

We conclude, therefore, that from the evidence of both chemical and mineralogical composition the rock is a porphyry which has been enriched with the bases calcium, magnesium, and iron.

Further considerations are necessary before the method of this enrichment can be studied. (See p. 334, "The Origin of the Hornblende Schists.")

DIVISION B.—THE METAMORPHIC ROCKS.

These are found along the southern shore of the harbour. The outcrop is exposed between the levels of high and low water. Above high-water mark, as has been pointed out above, is a plain of marine denudation covered now by recent alluvium. On the other hand, the lowest ebb of the tide fails to disclose the limits of the outcrop. The main outcrop begins at Henderson Street, and strikes 15° S. of E. for a distance of 15 chains. The strike then varies to E.S E., and continues so for other 22 chains, when a southerly bend of the coast cuts off the outcrop.

The rocks are traversed by numerous nearly vertical foliation-planes, which divide them up into layers of varying thickness. The joints have been mistaken for bedding-planes by previous investigators, who have recorded a dip varying from 84° to vertical.

There is another outcrop of the rocks further up the harbour, at Green Point, but here they are less metamorphic. They strike west-north-west to east-south-east.

The rocks are readily divided into two main kinds. One is a coarse dark-coloured rock consisting, as may be seen in the hand-specimen, almost entirely of hornblende. It forms the basic class of this paper. In the other rocks hornblende is also apparent, but no well-formed crystals may been seen in hand-specimens, as the rocks are much finer grained and more schistose in character. They form the acid class in this paper.

Class I.—Acid Metamorphic Rocks.

These rocks vary much macroscopically in the amount of hornblende and biotite, but under the microscope all prove to be varieties of hornblende scist.

1. Hornblende Schist.

Two complete series of sections were made from varieties of rock obtained by crossing the strike at right angles. Series A was obtained along the line marked AB on the map (fig. 2). Series B was obtained along the line CD.

Notes of the microscopical examination of series A are appended.

A 1. — Low-water mark, 157 ft. from high-water mark. Feldspar phenocrysts fairly abundant; cloudy and decomposed; some contain needles of hornblende. Hornblende in small crystals; especially numerous in the vicinity of feldspars; parallel arrangement. A little biotite. Grains of quartz, magnetite, and feldspar form groundmass.

A 2.—97 ft. Much the same as A 1.

A 3.—67 ft. Phenocrysts of feldspar, some showing Carlsbad twinning, decomposing as in A 1 and A 2. Increase of hornblende relative to feldspar compared with A 1 and A 2. A little epidote. Groundmass as before.

A 4.—37 ft. Hornblende still more prominent. Feldspar phenocrysts much smaller and more decomposed. Schistose structure marked. Magnetite abundant in groundmass.

A 5. — 7 ft. Hornblende dominant; longitudinal axes of crystals parallel. No phenocrysts of feldspar. Magnetite abundant. A little epidote. Groundmass grains of feldspar and quartz, feldspar predominant.

A 6.—High-water mark. Rock chiefly hornblende. Schistose structure perfectly shown. One section showed remains of a feldspar phenocryst. Grains of feldspar, quartz, and magnetite, and other accessories between crystals of hornblende.

As will be seen from the map, the B series is actually a continuation of the A series. It is not necessary to describe the rocks in detail. They are perfectly schistose in structure. Half the rock is hornblende. There are no phenocrysts of feldspar, but the grains of quartz and feldspar in the groundmass are clear, as though due to recrystallization. Biotite is more abundant.

Summing up the results of the examination of this series of rocks, we find that—(1) the phenocrysts of feldspar are more and more broken

down the nearer they are to the plutonic mass; (2) the decomposition of the feldspar phenocrysts corresponds to an increase in the amount of hornblende in the rock.

These facts will be made use of when we discuss the origin of the hornblende schists (p. 334).

Chemical Composition.—A sample of specimen No. 4, series A, was submitted to chemical analysis, with the result given in the following table. This analysis probably represents the average composition of the schists, though microscopical examination of sections leads one to expect more acid results in the case of the outer members of the series, and more basic results in the case of those nearer the norite.

SiO_2	61·00
TiO_2	..
Al_2O_3	13·66
Fe_2O_3	2·43
FeO	10·83
MnO	..
CaO	7·35
MgO	1·44
K_2O	0·52
Na_2O	1·90
Loss on ignition	1·20
Total	100·33

Specific gravity, 2·56.

Class II.—Basic Metamorphic Rocks.

1. Amphibolite.

Parallel with the series of hornblende schists just described is a band of coarse hornblende rock. The outcrop commences at a point 330 ft. from the shore-line measured along the line CD on the map, and extends below the level of low water a distance of 27 ft.

Hand-specimen (specific gravity = 2·94).—A coarse-grained black or dark-green rock. The weathered surface is rough on account of the exposure of large crystals of hornblende. A freshly broken specimen shows the bright cleavage surfaces of the hornblende. The rock appears to be almost wholly crystalline, there being but a small quantity of a dark-coloured matrix. There is no appearance of schistosity.

Under the Microscope.—The rock contains a very little feldspar in small grains in granular masses of dark hornblende. The rest is hornblende, a pale watery-green variety, feebly pleochroic, and fibrous in structure, all of which characters identify it as the form known as uralite. Where the fibres of uralite are packed together into large groups it is easy to recognize some of the edges of former crystals of pyroxene, but more commonly the fibres have broken away from the mass, inducing a schistose character.

That uralitization has taken place in the amphibolite can be proved in a most satisfactory manner. At Green Point several dykes of a diabase, a rock mineralogically and chemically similar to but less metamorphic than this amphibolite, are found, striking north-west to south-east. One of the dykes has suffered to a very considerable extent from the effects of weathering. In consequence of this, crystals are found to

project from the weathered surface, and can readily be removed from the soft matter that encloses them. These crystals exhibit to perfection the form of augite, but when sections of some of them were made they all proved to consist of a core of colourless augite surrounded by a margin of uralite.

These facts are of great significance. If the strike of these dykes be continued it is found that they may be expected to appear as outer members of the hornblende-schist series lower down the harbour. There is, therefore, no doubt that the amphibolite is a continuation of these dykes, but that, being in closer proximity to the norite, it has suffered metamorphism and uralitization to a greater degree.

No lengthy explanation of the name applied to this rock need be offered, as all authorities use the term for rocks "more or less markedly schistose in which hornblende is the dominant mineral."

The chemical composition is given below :—

SiO_2	49·75
TiO_2	..
Al_2O_3	17·75
Fe_2O_3	5·14
FeO	8·75
MnO	..
MgO	3·49
CaO	13·20
K_2O	0·37
Na_2O	2·30
Loss on ignition	1·00
Total	101·75

Specific gravity, 2·94.

The Contact of the Amphibolite and the Hornblende Schists.—At the line of junction these two rocks are more easily recognized in hand-specimens than they are under the microscope, for the causes that produced the metamorphism in both tended to bring about an exchange of material between the two. Thus the amphibolite is richer in feldspar where it is in contact with the schists, and the schists are relatively enriched with hornblende.

THE PROCESS OF URALITIZATION.

So far as I can ascertain, no writer has yet put forward an exact definition of uralite, and there does not seem to be a consensus of opinion as to what varieties of secondary hornblende are covered by the term. For instance, Harker,* in discussing the decomposition of augite, says, "Another common alteration is the conversion to hornblende, which may be light green and fibrous (uralite) or deep brown and compact." On the other hand, Williams† mentions the fact that the uralite fringing the pyroxenes "exhibits a marked tendency to become compact along its outer edge." Again, Geikie‡ terms uralitization "the conversion of pyroxene into compact or fibrous hornblende."

* Harker, A., "Petrology for Students," 4th ed. (1908), p. 79.
† Williams, G. H., Am. Journ. Sci., vol. 28 (1884), p. 261.
‡ Geikie, "Text-book of Geology," vol. 2, 4th ed. (1903), p. 790.

Nevertheless, since perhaps the majority of authorities give prominence in their definition of this mineral to a fibrous or acicular structure, this distinction will be observed in the present paper, and the definition adopted here is as follows: Uralite, pale-green slightly pleochroic fibrous variety of hornblende, derived from pyroxene. The hornblende of the norite, therefore, though of secondary origin, is not in this paper referred to as uralite, for it is a compact variety, rather dark in colour, and strongly pleochroic.

Uralite was first described by Gustav Rose from a green porphyritic rock at Mostovaya, near Ekaterinburg, and at Kaminskaya, near Miask, in the Ural Mountains. It has since been observed from many localities. The microscopical study of rocks has shown the process of "uralitization" to be very common, and some authors regard many hornblendic rocks and schists to represent altered pyroxene rocks on a large scale.

The crystals obtained from the dyke at Green Point afford abundant and excellent material for the investigation of the changes that take place when augite is converted into uralite. These crystals are usually short and stout, and show an equal development of the unit prisms (110), the orthopinacoids (100), and the clinopinacoids (010), while the usual terminal faces, the plus pyramids ($\bar{1}11$), are also perfectly formed. Twinned forms, with the orthopinacoid (100) as twinning and composition plane, are also quite common.

The results obtained from an examination of sections of some of these crystals cut in various directions will now be given.

The Core of Augite: The internal core of augite is colourless, except where recrystallization has commenced.

Cleavage: The usual cleavage-lines are not very distinct in sections in the zone of the prisms, though they are seen well enough in cross-sections. What is very distinct in sections parallel to the ortho- and clino-pinacoids is a series of parallel lines which intersect the cleavage-lines at angles approximating 70° in sections parallel to the clinopinacoid, and at right angles in sections parallel to the orthopinacoid. These lines thus represent a series of parting-planes parallel to the base (001), a not uncommon feature in augite.

Refractive Index: A rough surface in polarized light indicates the usual high value.

Pleochroism: Not noticeable.

Crossed nicols:

Interference colours: Bright tints of second order.

Extinction: In sections $\parallel a\,(100) = 37°$.

$b\,(010) = 0°$.

Alteration-products within the Mineral. — These are feldspar and hornblende in about equal amount and a little olivine. The decomposition begins at points on the cleavage-lines and proceeds most rapidly in the direction of them. The hornblende is dark green and strongly pleochroic. It extinguishes when the cleavage-lines of the augite are parallel to the vibration-directions of the nicols. The feldspar extinguishes at small angles. Olivine occurs in small grains; it is very rare. There is no trace of calcite, epidote, or chlorite, minerals that are commonly reported as associated with such changes as are here described. The fact that hornblende and feldspar are always associated as decomposition-products in the interior of the crystals suggests that the material derived from the decomposing augite is divided between

them, the calcium and magnesium going towards the formation of the one, the alkalies and alumina to the other mineral.

The internal decomposition of the augite seems in no way associated with the formation of uralite on its margins. The border of uralite is quite distinct, and shows no gradation towards the products of decomposition in the interior of the crystals.

The Fringe of Uralite.—Dana says in his "System of Mineralogy," "The crystals, when distinct, retain the form of the original mineral, but have the cleavage of amphibole. The change usually commences on the surface, transforming the outer layer into an aggregation of slender amphibole prisms, parallel in position to each other and to the parent pyroxene. When the change is complete the entire crystal is made up of a bundle of amphibole needles or fibres."

Present Observations.—The fringe of uralite varies in width with the size of the crystal, indicating that the amount of change varies as the surface exposed. Usually, however, it is noticed that the change has taken place more rapidly in the direction of the vertical axis than in the other directions, for the fringe bordering the terminations of the crystals is wider than that bordering prismatic faces.

Statements about the parallel arrangement of the prisms of uralite do not find support in an examination of the sections of the Green Point crystals, for the fibres are seen to be arranged in radiating groups which show no signs of systematic arrangement. Between crossed nicols some of these groups, or parts of the groups, are extinguished, while other groups are not. Each fibre extinguishes at an angle that varies from 15° to 18° to the direction of the longest axis, so that a dark wave traverses the group as the nicols are rotated.

In sections parallel to the clinopinacoid the groups commonly make an angle of 45° with the edge of the crystal, measured either in a + or − direction. In sections parallel to the macropinacoid and to the base these groups are commonly parallel, and the fibres show straight extinction. This seems to indicate that the fibres are arranged in fan-shaped aggregates parallel to the clinopinacoid, and making angles of about 45° with the macropinacoid.

Rosenbusch* states that the fibres are parallel, and that the vertical axis is the same in the parent mineral as in the new one. Also, that in the case of a twinned crystal the fibres of uralite stand in twinned position on opposite sides of the twinning-plane. With regard to this latter statement, an occurrence in one section shows quite a different state of affairs. The twinning-plane is distinct enough in the augite, but disappears completely on the verge of the uralite fringe.

Chemical Changes.—So far as present knowledge goes, the composition of uralite is believed to conform nearly to that of actinolite. The most prominent change in passing from the original pyroxene is that corresponding to the difference existing between the two species in general—that is, an increase in the amount of magnesia and a decrease in that of calcium. Analyses of the Bluff minerals are compared below with results given in Dana's "System of Mineralogy." In the absence of other means of separating the materials the following process was

* Rosenbusch-Iddings, "Microscopical Physiography of the Rock-making Minerals," 4th ed. (1900), p. 271.

resorted to: Having made a sufficient number of sections to ascertain the thickness of the covering of uralite, crystals were ground down on all faces to remove this portion. The remainder provided material for an analysis of the core of augite. From other crystals thin flakes were cleaved, and the analysis of these was taken as representing the composition of the uralite.

	A.	B.	C.	D.
SiO_2	49·95	49·80	50·87	52·82
Al_2O_3	5·32	6·21	4·57	3·21
Fe_2O_3	3·57	4·26	0·97	2·07
FeO	7·85	9·61	1·96	2·71
MnO	..	..	0·15	0·28
CaO	23·45	14·80	24·44	15·39
MgO	7·57	12·39	15·37	19·04
K_2O	Undet.	Undet.	0·50	0·69
Na_2O			0·22	0·90
Loss on ignition ..	0·36	2·50	1·44	2·40
Totals ..	98·07	99·57	100·49	99·51
Specific gravity ..	3·00	2·6315	3·181	3·003

A. Augite. From dyke of amphibolite, Bluff.

B. Uralite. Forming exterior of A.

C. Central portion of pyroxene crystal, Templeton, Quebec. (Anal., Harrington, Geol. Canada, p. 21, 1879.)

D. Amphibole forming exterior of C. (Anal., Harrington, Geol. Canada, p. 21, 1879.)

These analyses emphasize the change in the relative amounts of magnesia and calcium. There is also in the case of the uralite a rise in the percentage of alumina and iron-oxides corresponding to a fall in the total percentage of magnesia and calcium. This is what we might expect in the case of a mineral derived from another mineral by hydro-chemical processes. The process of uralitization is commonly reported to be accompanied by the separation of calcite and by the formation of epidote.* In the case of the Green Point minerals the augite undoubtedly loses calcium, but neither calcite nor epidote are seen as decomposition-products.

Both sets of analyses emphasize the fact that the change of augite to uralite is not strictly a case of paramorphism, though usually so designated.

The causes that led to the production of uralite are discussed later under the heading "The Origin of the Amphibolite."

III. Relationship between the various Rock Types.

It has already been stated that there is a close relationship existing between the porphyry and the hornblende-schist series. The relationship between the amphibolite and the hornblende schists also requires explanation, and it must also be shown what part the intrusion of the norite

* See, *e.g.*, "Microscopical Physiography of the Rock-making Minerals," Rosenbusch-Iddings, 4th ed. (1900), p. 271.

has taken in producing or altering the various rock types. Perhaps the best way of opening up these questions will be to discuss independently the origin of the metamorphic rocks, and a subsequent paragraph will deal with the relative age of all the rock types.

An attempt will now be made to deal with these problems.

A. Origin of the Hornblende Schists.

To an observer traversing the schist area described above, the solution of the problem seems evident. The rocks are hornblende schists, apparently well bedded, and inclined at various high angles. Intruded into them is a mass of igneous rock. The suggestion at once occurs that the rocks are the result of the metamorphism of a series of sediments, produced by the igneous intrustion.

Hutton* first put forward this view in 1872, referring to the rocks as slates and sandstones, some argillaceous and some arenaceous.

Park† made similar statements in 1887, and added, "Tewaewae Point, on the mainland opposite to the Pilot-station, appears also to be formed of sedimentary rocks, but I had no opportunity of determining this." This is the view at present held as to the origin of the schists.

A visit to Tewaewae Point, however, and an examination of the rocks that actually do occur there, at once raises grave doubts as to the correctness of this view. For there we find not a sandstone, but a typical porphyry. Microscopical examination shows evidence of strain in the undulose extinction of some of the feldspars, and metamorphism is indicated in other ways. The feldspar phenocrysts are cloudy, they have irregular outlines, and new minerals are closely associated with their decomposition. The chief of these are hornblende, mica, and iron-ores. The rocks are traversed by joints striking in the same direction as those found in the schists. The outcrop disappears below low-water mark, and presumably reappears on the other side of the harbour. At any rate, I have the assurance of the Engineer of the Bluff Harbour Board that rocks outcrop *in situ* right across the channel.

Microscopical examination of the members of the schist series shows that the outermost members contain comparatively large phenocrysts of feldspar. These are much broken down, and are quite surrounded by microlites and crystals of hornblende. Associated with this is the separation of iron-ores, especially magnetite. As the norite is approached these residual feldspars are found to decrease in size, until finally with the innermost series they disappear completely. This gradual disappearance of the feldspars is found to correspond to a gradual increase in the amount of ferro-magnesian minerals, especially hornblende and iron-ores.

The groundmass of the porphyry consists of feldspar and quartz, and small flakes of hornblende and brown mica. The groundmass of the schist is essentially similar. The feldspar grains have been considerably comminuted, while an opposite process has taken place in the case of the hornblende and mica. The schists also contain secondary minerals, such as apatite and epidote.

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* Hutton, F. W., "Report on Geology of Southland," Rep. N.Z. Geol. Surv., 1871–72, p. 89.

† Park, J., "The Geology of Bluff Peninsula," Rep. N.Z. Geol. Surv., 1887–88, p. 72.

The analyses of the porphyry, the norite, and an intermediate member of the schist series are repeated here for comparison.

	Porphyry.	Schist.	Norite.
SiO_2	67·60	61·00	48·10
Al_2O_3	12·29	13·66	20·85
Fe_2O_3	3·15	2·43	4·85
FeO	4·88	10·83	10·55
CaO	2·90	7·35	7·15
MgO	1·08	1·44	3·99
K_2O	2·16	0·52	0·63
Na_2O	5·67	1·90	2·73
Loss on ignition	0·15	1·20	1·00
Totals	99·88	100·33	99·85
Specific gravity	..	..	2·68

These considerations—namely, the field relations of the rocks and their mineralogical and chemical compositions—lead to the conclusion that the hornblende schists are derived from the porphyry by metamorphism induced by the intrusion of the norite. The porphyry has become sheared by enormous pressure, so that it has become foliated, and its original character is masked.

The thermal metamorphism of igneous rocks has received comparatively little attention, and geological literature available to me presents no comparisons with the area to which this paper refers, and gives no description of the chemical changes that take place in similar circumstances.

In the case under consideration the principal changes to be accounted for are the destruction of the phenocrysts of feldspar in the porphyry, the devitrification of the glassy portions of its groundmass, and the great increase in the amount of the ferro-magnesian constituents.

The first two points can be explained by the ordinary processes of hydro-, thermo-, and dynamo-metamorphism, all of which would be active at the time of the intrusion of the norite. The water would be partly magmatic and partly meteoric.

The third point, however, involves the supply of large quantities of calcium, magnesium, and iron for the formation of the ferro-magnesian minerals, for the supply in the original porphyry was by no means sufficient, and, in any case, the chemical analyses show that a large quantity has been introduced.

The norite we may at once presume was the store from which the supply of these elements was derived, for the norite magma is very rich in them.

Transference of Material from the Norite to the Porphyry.—Percolating water is universally recognized as a most potent agent, especially at such high temperatures as would obtain in the case of a plutonic intrusion. The small percentage of water in schists — 1 per cent. by weight or 2 per cent. by volume—is held to be sufficient to account for all the recrystallization that has taken place in rocks that are completely metamorphosed. The solubility of minerals increases greatly when they are in a state of strain. All these facts are well attested.

All the conditions for solution and recrystallization were abundantly present in the case under consideration. The intrusion of the norite produced a high state of strain in the porphyry. There is still evidence of this in the strain shadows observable in the feldspar phenocrysts at Tewaewae Point, and the strain must have been much greater in rocks nearer the intrusion. This is shown in the schists by the number of shearing-planes, often but a few inches apart.

The temperature of the intruded mass must have been very high, and the cooling must have been prolonged, for the norite is holocrystalline and of coarse grain.

Water would be present in sufficient amount, as percolated meteoric water in the porphyry perhaps, but more probably the supply would be the magmatic waters from the norite itself.

B. The Origin of the Amphibolite.

Of amphibolites Harker* says, "The name 'amphibolite' has often been applied to rocks, usually more or less markedly schistose, in which hornblende is the dominant mineral. Many of them are doubtless the results of dynamic action on diorites, and sometimes on dolerites and gabbros."

Teall† describes the formation of a hornblende schist from a dolerite (or diabase) from two dykes which occur in the Archaean gneiss of the north-west of Scotland, near the Village of Scourie.

A comparison of his analyses with that of the Bluff amphibolite is instructive:—

	A.	B.	C.
SiO_2	47·45	49·78	49·75
TiO_2	1·47	2·22	..
Al_2O_3	14·83	13·13	17·75
Fe_2O_3	2·47	4·35	5·14
FeO	14·71	11·71	8·75
MgO	5·00	5·40	3·49
CaO	8·87	8·92	13·20
K_2O	0·99	1·05	0·37
Na_2O	2·97	2·39	2·30
H_2O	1·00	1·14	1·00
CO_2	0·36	0·10	..
Totals	100·12	100·19	101·75
Specific gravity	3·105	3·111	..

A. Dolerite (diabase?), Scourie, north-west Scotland.
B. Hornblende schist derived from A.
C. Amphibolite, dyke, Bluff, derived from diabase.

Teall's conclusions are: "(1) That the hornblende schist of the Scourie dykes has been developed from a dolerite by causes operating after the consolidation of the dolerite, and that the metamorphosis has

* Harker, A., "Petrology for Students," 4th ed. (1908), p. 326.
† Teall, J. J. H., "On the Metamorphosis of Dolerite into Hornblende Schist," Quart. Journ. Geol. Soc., vol. 41 (1885), p. 142.

been accompanied by a molecular rearrangement of the augite and feldspar; and (2) that the molecular rearrangement has in certain cases taken place without the development of foliation."

Other cases of the formation of hornblende schist from igneous rock have been described by Allport,* who, in his summary, expresses the opinion that "hornblende schists may be metamorphosed igneous rocks, some being derived from dolerites or gabbros, while others are very probably foliated diorites."

These considerations, in conjunction with the chemical and mineralogical composition and the structure of the rock, suggest that our amphibolite is derived from the metamorphism of a basic igneous rock. Furthermore, at Green Point there actually does occur a basic igneous dyke rock consisting chiefly of augite in process of uralitization, and striking in a direction such as to indicate its identity with the amphibolite of the Lower Harbour series.

There yet remains to be shown the causes that produced the change to amphibolite.

Williams† points out that augite appears to be the stable form at high temperatures and hornblende at low temperatures. The change, therefore, must have been subsequent to the consolidation of the dykes, for at the time of intrusion the temperature would have been too high to admit of the formation of hornblende.

We have, therefore, to supply some conditions such as would facilitate molecular readjustment in the augite crystals after consolidation. Such conditions would certainly attend the intrusion of the norite. We need not assume, however, that the intrusion of the plutonic mass at once produced uralitization of the augite. On the contrary, the heat attending the intrusion may have been so high as to prohibit the formation of hornblende. The important point is that a state of strain was induced throughout the whole intruded mass. Evidence in support of this statement has been given above. This condition of strain would continue to exist after the consolidation of the norite, and when the temperature had again fallen to normal. Then would commence the process of uralitization, and it would be assisted by the percolating waters that aided in the metamorphism of the porphyry.

The conclusions here are, therefore, similar to those of Teall in the case of the Scourie dykes. The amphibolite is derived from a diabasic rock by metamorphism that most probably acted after the consolidation of the diabase, and was accompanied by a molecular readjustment of the augite.

C. Relative Age of the Rocks.

The porphyry and the rocks derived from it—that is, the hornblende schists—are the oldest rocks, for into them the other rocks have been intruded.

Of the intrusive rocks, we assume that the diabasic dykes are older than the norite, for the diabase is metamorphosed to an amphibolite, and the metamorphism is presumably connected with the intrusion of the norite.

* Allport, "On the Metamorphic Rocks surrounding the Land's End Mass of Granite," Quart. Journ. Geol. Soc., vol. 32 (1876), p. 407.

† Williams, G. H., Am. Journ. Sci., vol. 28 (1884), p. 259.

IV. Age of the Rocks.

A. Age of the Metamorphic Rocks.

Hector early classed the hornblende schists in his Te Anau series on account of their lithological resemblance to rocks of the typical area. He referred the Te Anau series to the Devonian period, because in Nelson Province the rocks were thought by him to underlie the Maitai slates, which were classed as of Carboniferous age.

Hutton,* in 1875, placed the rocks in his Kaikoura formation, corresponding to the Te Anau series of Hector. Of the age of the Kaikoura formation he says, "As it underlies quite unconformably the Maitai formation, which is of Lower Jurassic or Triassic age, we may consider it for the present as belonging to the Carboniferous period."

In 1877 Hector† placed the Te Anau series in the Maitai system, to which he now ascribed a Triassic age. Subsequently, however, he gave up this correlation, and the Maitai system was referred back to the Carboniferous age.

In 1885 Hutton‡ gave up his name of Kaikoura formation in favour of the nomenclature of Hector. At the same time he adopted the correlation of the Geological Survey for the Maitai system.

In 1877 Park§ reported on the Bluff Peninsula at the instance of the Geological Survey Department. He says, "There is only one sedimentary formation represented in this area, and, although it contains no fossil remains, it is referred to the Te Anau series, to which the mineral character of its rocks have some resemblance."

In his latest work Park‖ refers to these schists as argillites. In one place (p. 42) he says they are "of the Wangapeka formation (Manapouri system, Silurian age)"; in another place (p. 46) they are "argillites that belong to Kakanuian or Middle series (Ordovician age) of the Manapouri system."

Present Conclusions.—In the entire absence of palaeontological and stratigraphical evidence we have to rely solely on lithological evidence. Previous investigators have apparently failed to recognize the extremely metamorphic state of the schists, and have assigned to them a correlation that their original nature does not justify.

The dykes of diabase at Green Point (amphibolite in the schist series), however, are rocks similar to those of the Te Anau series—namely, greenstones, aphanite, breccias, or greenstone breccias in the Te Anau-Wakatipu area, and diabase and diabase breccias in the Nelson District. In the absence of other evidence, therefore, we shall place the basic dykes in the Te Anau series of the Maitai system. The porphyry, therefore, and the hornblende schists will be somewhat older than the basic dykes, but there is at present no reason to remove them altogether from the same series.

B. Age of the Intrusive Rocks.

The evidence for the age of the plutonic rock is even more scanty. Park, in 1887, thought the mass was of late Carboniferous age, for he

* Hutton, F. W., "Geology of Otago" (1875), p. 36.

† Hector, Rep. N.Z. Geol. Surv., 1877.

‡ Hutton, F. W., "Sketch of the Geology of New Zealand," Quart. Journ. Geol. Soc., vol. 41, p. 191 *et seq.* (1885).

§ Park, J., "The Geology of Bluff Peninsula," Rep. N.Z. Geol. Surv., 1887–88, p. 72.

‖ Park, J., "Geology of New Zealand," 1910.

mistook the rock for syenite, boulders of which were thought to be found in the Hokonui Hills, of Permian age. It is now known that there is no rock resembling the norite in the Hokonui conglomerates.

In his "Geology of New Zealand," recently published, Park makes no definite statement of the age of the norite intrusion, beyond discussing it under his Manapouri system, which includes series of Cambrian, Ordovician, and Silurian age.

There is, in fact, no evidence that accurately fixes the age of this intrusion. We know definitely that it is younger than the intruded rocks—that is, late or post Carboniferous. Very probably the intrusion is connected with the widespread elevation that in Jurassic times enlarged New Zealand to continental dimensions. This movement resulted in rock-folding, and the main mountain-ranges were formed. The folding was associated with the intrusion of igneous rocks in various localities.

Art. XXXVI.—*The Anatomical Structure of the New Zealand* Piperaceae.

By Anne F. Ironside, M.A.

[*Read before the Manawatu Philosophical Society, 20th April, 1911.*]

The *Piperaceae* have formed the subject of much research recently, by Campbell, Johnson, and Hill, to throw light on the relationships of the order. and on the phylogeny of the Angiosperms generally.

Hill's preliminary account on seedling-structure in the order appeared in the "New Phytologist," No. 3, 1904; the full account appearing in the "Annals of Botany," April, 1906. He gives a comprehensive account of seedling-structure in *Piper cornifolium* and in many *Peperomias*, then a description of development in the *Saurineae*, the whole concluding with certain theoretical conclusions. Hill, in common with Johnson, looks on *Peperomia* as a reduced genus; but he suggests that this reduction may be due to the epiphytic character of many of the species.

The object of the present investigation was the examination of the anatomical structure of the mature plant and seedling of the New Zealand representatives of the order, to see what bearing they had on the subject. The work was commenced at the Auckland University College some three years ago. My thanks are due to Professor A. P. W. Thomas for the assistance he rendered me.

New Zealand Representatives.

There are three representatives of the order:—

1. *Macropiper excelsum* is either a shrub, forming a common undergrowth, or a small tree, often 20 ft. in height, aromatic, glabrous. Stem flexuose, jointed. Leaves 3–5 in. long, broadly ovate-cordate, often sharply pointed; petioles 1–2 in. long, with sheathing base, which serves as a protective organ. Catkins solitary or 2 together, axillary, erect, slender 1-4 in. long; berries yellow.

2. *Peperomia Endlicheri* (*P. Urvilleana* of Hooker, 20) is a small creeping, succulent herb. Grows in damp woods, on rocks, less often on trees.

3. A second *Peperomia*, which is probably identical with the *Peperomia reflexa* of Australia and many tropical countries, is not very common in New Zealand, and was not obtainable for investigation.

Anatomical Features.

Stem.

The woody stem of *Macropiper excelsum* shows the double ring characteristic of the woody *Piperaceae*. In a transverse section we find on the outside periderm; beneath is cortical tissue. A young stem shows a distinct epidermis, the cells of which are more or less oblong in outline; immediately below are from 2 to 3 rows of cells, showing tangential divisions. It is from these we have the periderm.

Below the epidermis, or periderm, is well-marked collenchyma, especially thick behind the bundles. De Bary refers to a similar structure in *Piper rugosum:* "The hypodermal layer surrounds the whole stem as a distinct closed, multiseriate (collenchymatous) layer." The collenchymatous layer consists of from 8 to 10 layers, narrowing to less layers with slightly wider elements between the bundles.

Immediately beneath this is a discontinuous ring of sclerenchymatous elements, one or two elements wide, abutting at places on the vascular bundles; longitudinal sections show these elements to be branched occasionally.

Then comes the outer ring of bundles, each bundle separated by a wide medullary ray from its neighbour. The bundles of this ring show secondary thickening to a marked degree. On the inside of this ring is a sclerenchymatous band several layers thick, broken occasionally between two bundles (fig. 2).

In the centre of the stem is medulla, in which is a ring of separate bundles. In stems $\frac{3}{4}$ in. to 1 in. broad there are about 10, but the number varies in accordance with the size of the stem; 3 to 4 is common in young parts, especially seedlings.

On the outside of each bundle both of the outer and often of the inner ring are much-thickened sclerenchymatous elements. Then there is the inner sclerenchymatous band. De Bary, remarking on the inner sclerenchymatous band, says, "The converse case, that a continuous layer of sclerenchyma supports the whole inner side of the ring of vascular bundles, is rare in Dicotyledons. This is the case in the woody *Piperaceae—Artanthe, Chavica* sp."

In some stems—*Ranunculus repens*, for instance—we find sclerenchymatous elements on both sides of the bundle, representing a sheath. It is probable that in the *Piperaceae* these sclerenchymatous elements represent the bundle-sheath, which has become much thickened and extended on the inner side for mechanical purposes. There is sclerenchyma to the inside of each bundle of the medullary circle, but it does not form a continuous ring; also at the base of the stem, and in young branches coming from the base, as in fig. 6A, in seedlings the continuity of the ring disappears, all which lends to the view that the sclerenchymatous ring is an extended sheath.

The phloem consists of several layers showing deeply staining sieve-tubes and companion cells; sieve-plates, where cut through, show very fine pits.

The cambium shows especially well the tangential divisions for wood and bast formation. The cambial or merismatic region is continuous round the stem in the outer ring, though it is only where the cambial layer passes through the bundle that it gives rise to wood and bast. Between the bundles the tangential divisions increase to the medullary ray. In no instance are secondary bundles found between the primary bundles.

The wood, as is seen in longitudinal sections, shows pitted and scalariform vessels and pitted wood-fibres, besides annular and spiral elements of the protoxylem. Some of the bundles show the primary elements of the wood to be distinctly scattered: longitudinal sections and oblique

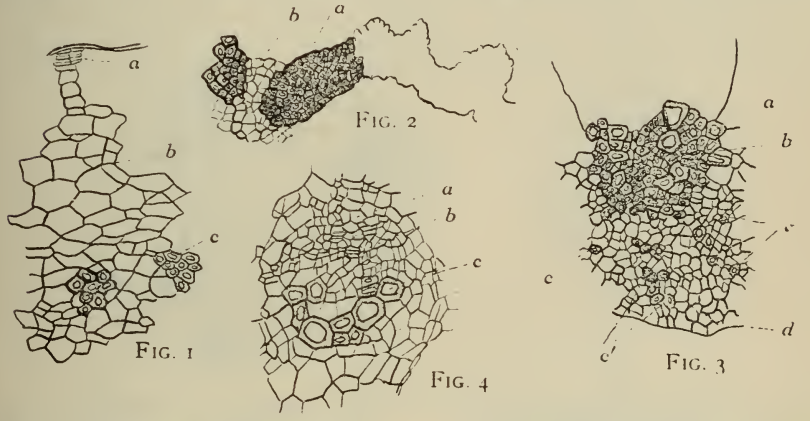

Fig. 1. Outer tissues, young stem: *a*, epidermis; *b*, collenchyma; *c*, sclerenchyma. × 150. *M. excelsum.*

Fig. 2. Portion of sclerenchyma band: *a*, sclerenchyma; *b*, medulla at break in ring passing into medullary ray. × 44. *M. excelsum.*

Fig. 3. Inner portion of bundle from outer ring, showing scattered primary xylem: *a*, secondary xylem; *b*, wood-fibres; *c*, *c′*, protoxylem to sides and to inside of bundle; *d*, boundary of sclerenchymatous band. × 44, *M. excelsum.*

Fig. 4. Bundle from stem: *a*, phloem; *b*, cambial region; *c*, xylem. × 150. *Peperomia Endlicheri.*

transverse sections show the protoxylem in many cases to be endarch, but there are frequently scattered elements to the sides of the bundle as well (see fig. 3). The question is, Is this a trace of centripetal wood-formation?

In the medullary bundles secondary-wood formation does not take place to the same extent as in the outer ring.

On the inside of the wood, in the bundles of both rings, are a fair number of parenchymatous elements. At first sight they look like internal phloem, but on examination of young stems, and especially of those bundles of the inner ring where there are very few lignified elements, it is seen that these are only parenchymatous elements. Some bundles show only 6 to 8 lignified elements in a mass of tissue staining deeply with haematin. As more wood is formed, more of this becomes lignified also, but a little to the inside always remains unlignified. In bundles where the primary xylem is scattered, the elements are scattered through parenchymatous elements.

The medullary rays are very wide, sometimes 5 to 6, often 10 to 12 elements wide, parenchymatous mainly; in older stems slightly lignified.

Young stems, the base of the stem, and to a less extent an older stem, show the central medulla and medullary rays thickly set with starch.

Engler has said that in *Macropiper heckeria*, *Piper chavica*, the bundles are in rings, the outer bundles joined. In *Macropiper excelsum* the bundles of the outer ring are separated by very wide medullary rays, as already stated. Tangential sections can also be cut in which the medullary ray is continuous right through. A portion of the internode of the woody stem was boiled for some time in water, and the outer tissues stripped off. The bundles showed only an occasional join. Some of the bundles could be separated throughout almost the whole length of the piece, 2 in. There is no network of anastomosing. A join is effected by a branch of very

FIG. 6

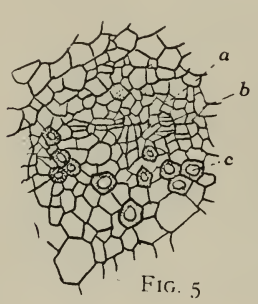

FIG. 5

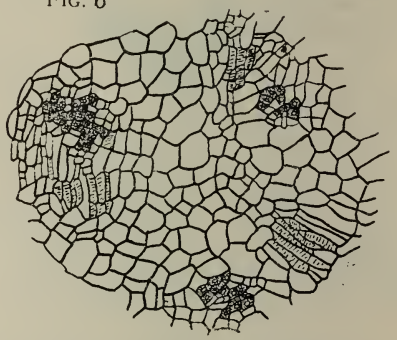

Fig. 5. Bundle from stem, showing xylem scattered: *a*, phloem; *b*, cambium, *c*, xylem. × 150. *P. Endlicheri.*

Fig. 6. Joining among central bundles in lowest internode seedling (see fig. 6A, *b*). × 44. *M. excelsum.*

few elements. A longitudinal face shows no anastomosing. Hence it must be concluded that the outer ring of bundles in *Macropiper excelsum*, at least, is only occasionally branched. Branching and forking of the bundle takes place at the nodes.

Peperomia Endlicheri.

Peperomia Endlicheri is a rock-plant, less often an epiphyte. Its stem is succulent, its leaves store water. A cross-section through the stem shows on the outside an epidermis of narrowish elements. The cortex is succulent, and shows oil-sacs. The presence of oil is highly characteristic of the *Piperaceae*. Here, as in *Piperaceae* generally, the oil-sac consists merely of one of the cells of the cortex. Strasburger and De Bary both make reference to the ethereal oil found in Pipers; Engler says mucilage passes in the epidermis and cortex, but the walls of the passages do not differ from those of the cells around; the contents give a pungent odour to the plant.

Scattered in the ground tissue of *P. Endlicheri* are bundles showing an arrangement as in many Monocotyledons. But in *Peperomia*, as Engler an others point out, the bundles have a cambium. In the New Zealand *Peperomia*, however, the activity of the cambium is at a minimum The amount of lignified tissue always remains small. There is no definite arrangement in this species in rings; whereas in some *Peperomias* there are rings. In *Peperomia galioides* there are two rings of five.

The petiole of *P. Endlicheri* shows one large central bundle and two smaller ones, one on each side of the central one. The leaf shows an epidermis consisting of several layers, as seen in many *Peperomias*. The mesophyll-cells are also large, contain but very little chlorophyll, and store water.

Base of Macropiper.

The base of *M. excelsum* is swollen, and stored with nutritive material (fig. 6A). This is shown even in young specimens. The nutritive material chiefly takes the form of starch, which is contained in the medullæ and medullary rays, and also in the cortex.

In the young branch coming from the base of the stem the stem shows two rings of vascular bundles, as usual. But the sclerenchyma appears only on the inside of each bundle of the outer ring; there is no continuous band of sclerenchyma, though there are occasionally slight indications of

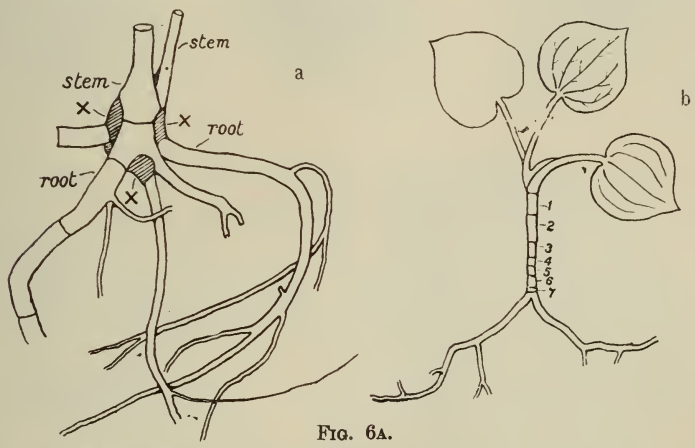

FIG. 6A.

a, Base of *M. excelsum* (× scars where stems have been broken off); *b*, young seedling, half life-size.

extension of thickening between the bundles. The more usual number of bundles in the medullary circle in the youngest parts seems to be three. As one passes up the stem the sclerenchymatous elements gradually form a continuous band.

Coming to the main stem, near the base in the region marked 1 in fig. 6A, *b*, there is a distinct corky layer outside with a collenchymatous band below. The structure of the rings is much the same as higher up the stem, but there is abundant starch everywhere. The bends of the sclerenchymatous ring, also, are here much deeper, and extend more into the interior of the stem.

As one passes down to region 2 the sclerenchymatous ring gradually disappears, and sclerenchyma occurs only to the inside of each bundle, extending over into the medulla in more or less club-shaped, rounded masses. The discontinuity of the sclerenchyma probably allows for the easy passage of food-material. Each of the central bundles is seen to be formed by the fusion of a bundle, or bundles, of the outer ring with a central bundle of the internode above. Fusion invariably starts at the xylem end, some bundles distinctly showing two masses of xylem at each side of a central line.

In region 3 the fusion of bundles of the outer ring with medullary bundles is traced, but the whole is gradually merged in the one ring typical of the structure of the subsidiary roots in *M. excelsum*.

Hypocotyl.

The details of transition in the hypocotyl in *M. excelsum* were not at all rigid. There are six plumular traces, which are arranged on either

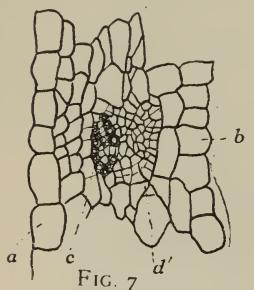

FIG. 7

FIG. 8

FIG. 9

Fig. 7. Transverse cotyledon, *M. excelsum*, passing through midrib: *a*, upper; *b*, lower epidermis; *c*, xylem; *d*, phloem. × 150.
Figs. 8 and 9. Hypocotyl below entry of cotyledon-traces. × 150.

side of the axis in threes. These appear to fuse together, the xylems first of all. A single cotyledonary trace enters from each cotyledon. On its entry the phloem is found in two masses on either side of the xylem; the elements travel towards the centre, and leave the protoxylem exarch, as in *Peperomia amplexifolia*, *P. tithymaloides*, and *P. maculosa*. The phloem masses ultimately fuse with the plumular phloem; as the xylem from the plumular traces moves also towards the centre a central plate of xylem is formed; and we find a typical diarch structure. But the plumular xylem may be very small in amount; so that, as in *Piper cornifolium*, the central plate is composed mainly of elements derived from the cotyledonary traces. But in one seedling examined the plate was composed mainly of elements derived from the plumular traces, while the mesarch elements from the cotyledonary traces decreased in amount. The plumular traces showed lignified tissue, and were not wholly meristematic, as in *Piper cornifolium*.

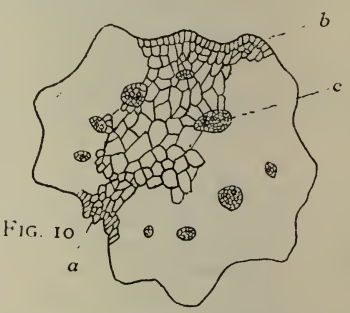

FIG. 10

Transverse petiole, young plant of *M. excelsum*: *b*, dorsal; *a*, ventral side; *c*, bundle. × 44.

Root—Macropiper excelsum.

In *M. excelsum* the roots are adventitious. The primary root is very early lost. On uprooting the plant one finds it characteristically forked. Very often a seedling bearing only the two cotyledons has lost its primary root.

The structure was carefully examined. Secondary thickening is developed to a marked degree, and is especially noticeable near the base of the stem. The bundles form a ring, each separated by wide medullary rays, which are always densely granular. The medulla is also stored with starch.

Sections through the base of the stem and the seedling show that the bundles in the root are continuous with those of the stem; the ring of the stem gradually passes over into that of the root. The centripetal xylem in the root can be traced between the bundles, and sometimes occurs as

FIG. 11

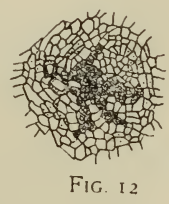

FIG. 12

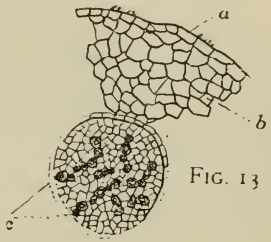

FIG. 13

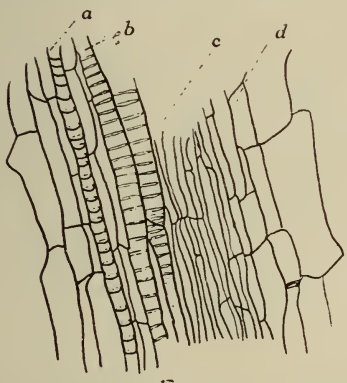

FIG. 14

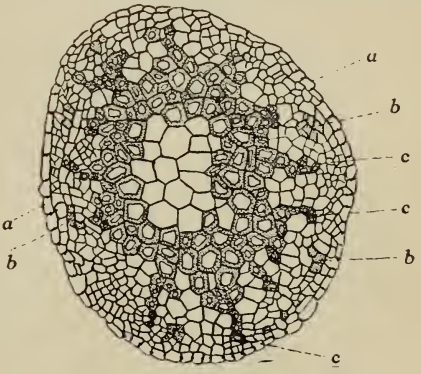

FIG. 15.

Fig. 11. Hypocotyl, showing endodermis. × 150. *M. excelsum.*
Fig. 12. Shows splitting of xylem plate. × 150. *M. excelsum.*
Fig. 13. Root, *Peperomia:* 6 protoxylems, *c*; *b*, cortex; *a*, piliferous layer.
Fig. 14. Stem, *Peperomia*, longitudinal: *a*, annular vessels; *b*, secondary xylem; *c*, phloem; *d*, cortical tissue. × 150.
Fig. 15. Stele from root, older plant: 8 protoxylems, *c*; 8 phloem masses, *b*; *a*, endodermis. Small amount of central medulla. × 150. *M. excelsum.*

scattered elements. Scattered elements often occur in the stem, to the sides of the bundle; so it would seem that there are traces of centripetal xylem in the stem. Again, in the peduncle, where one might expect to find ancestral traces, many of the bundles show small elements to the sides of the bundle.

Root—Peperomia Endlicheri.

In *P. Endlicheri*, on the other hand, we find a small stele in the root, with 6 (sometimes 6 to 8) protoxylems, but with very feebly developed xylem, so that there is no complete centripetal plate.

P. Endlicheri is a rock-plant, living on humus lodged in rock-crevices, or occurs as an epiphyte, but is never found on the ground. The roots are adventitious, and form mat-like masses at the nodes. In accordance with its habit, there is no need for great mechanical development, as in *Macropiper excelsum;* hence the root-structure is reduced. We may regard the structure seen in the root of *Peperomia Endlicheri* as a reduction from a type such as *Macropiper excelsum* (younger roots) in adaptation to environment.

Conclusions.

Several theories have been put forward as to the origin of Monocotyledons and Dicotyledons, and their relation to one another. One theory is that Dicotyledons have come from Monocotyledons, the connection being shown through the *Araceae* and *Piperaceae;* another that Monocotyledons have come from Dicotyledons; and, further, that Monocotyledons are diphyletic.

The result of the present investigations on the New Zealand *Piperaceae* has been to lead to the following conclusions concerning the *Piperaceae*, and the relations between Mono- and Di-cotyledons: That Monocotyledons and Dicotyledons have a common ancestry, though the point of

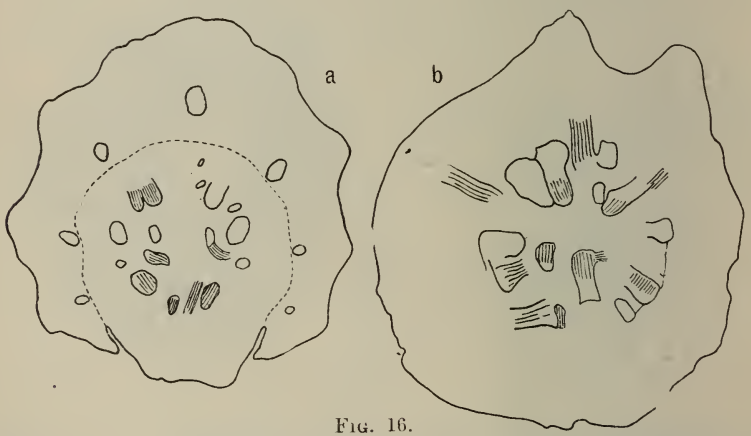

Fig. 16.

a. Seedling stem, showing sheath merging into stem; *b*, passing into lowest internode of seedling—leaf-traces passing in to outer ring, bundles passing in from outer ring to centre (diagrammatic).

convergence lies probably far back in time, the habit and structure of Monocotyledons being adaptations from the dicotyledonous form to their peculiar conditions of life. That *Peperomia* is a reduced genus, compared with *Macropiper;* that the connection between Monocotyledons and Dicotyledons may perhaps be shown by an order such as the *Piperaceae*, where the one form, *Peperomia*, shows a reduction from the *Macropiper* form, the reduction being in the direction of Monocotyledons. That the *Piperaceae* are relatively an ancient family. They show a relation or resemblance to Aroids, more particularly among Monocotyledons; the key to the connection between Monocotyledons and Dicotyledons may perhaps be found in a connection between the *Piperaceae* and *Araceae*.

Hill, who " is in full accord with this view, that *Peperoma* is a reduced genus," suggests " that the determining factor which has brought about

the reduction may be found in the epiphytic habit of many of the forms"; and later says, "Nothing has been said regarding the bearing of the geophilus habit exhibited by certain species of *Peperomia*."

Macropiper excelsum comes very near a geophilous condition in having a swollen base stored with food-material; the adventitious roots near the base and for some distance from it are also stored with starch. The plant is sometimes tall, sometimes short and more shrub-like. *Peperomia Endlicheri* occurs both as a lithophyte and chasmophyte, less often as an epiphyte. Under these conditions it has succulent stems and adventitious

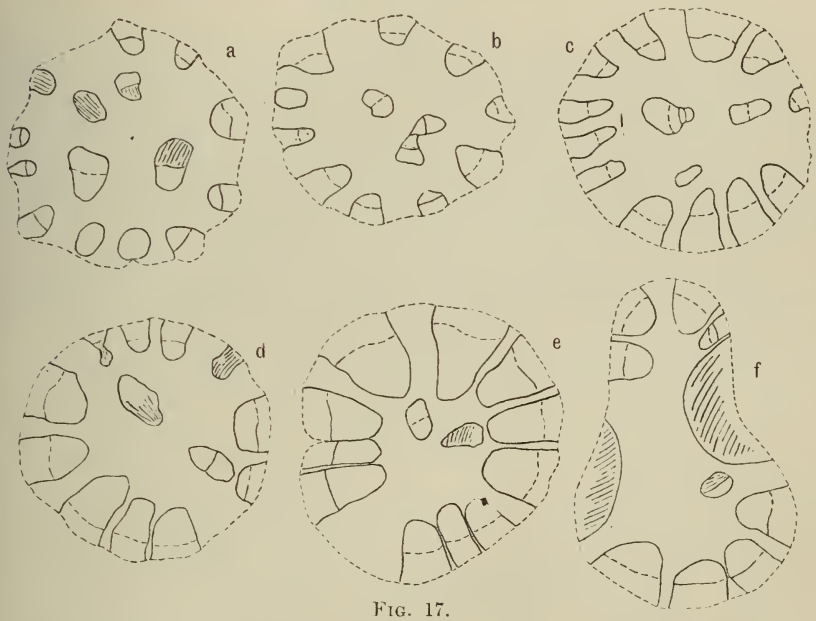

Fig. 17.

Six steles passing downwards through lowermost internode of seedling (diagrammatic): *a*, four bundles just formed again in centre; *b*, *c*, central bundles joining to form two; *c*, *d*, *e*, central bundles move further and further outwards till they are finally merged in outer ring; *e*, slightly elongated, passing out to root; *f*, stele with branch to root. All the steles are slightly eccentric with regard to rest of stem.

roots, both stem and root showing reduced structure. Now, very many Monocotyledons are adapted to suit geophilous, epiphytic, aquatic, or saprophytic conditions.

Stem-structure.

It has been shown (Miss Sargant) that in connection with a geophilous condition extra-fascicular cambium would first disappear; then the cambial zone, because the need for mechanical vascular tissue has disappeared. M. Queva has shown that a distinct cambial zone occurs with the bundles of some Monocotyledons, and traces of it in others. Now, in *Macropiper excelsum*, while there is no interfascicular bundle-formation, there is marked secondary thickening, necessary to its form. In some *Peperomias* the bundles are arranged in rings, as *P. galioides*. In *Peperomia Endlicheri* the scattered vascular system, and the fact that, though

a cambium is differentiated, still the amount of xylem formed remains constantly very small, point to reduction.

As a general rule, among herbaceous, bulbous, &c., Monocotyledons the primary root disappears with the cotyledons. In *M. excelsum* there is early loss of the primary root, and great development of adventitious roots; there are numerous adventitious roots from the nodes in *P. Endlicheri*. The loss of the primary root is, in all cases, probably connected with geophilous characters. Among the *Ranunculaceae*, which are admitted to be primitive, *Eranthus* shows the primary root replaced in the second spring by a circle of roots.

Leaf.

The leaf-venation seen in *M. excelsum* somewhat resembles that seen in such Aroids as *Zantedeschia*, *Arum*. Professor Areschong has remarked that the linear leaves characteristic of most bulbous Monocotyledons are better adapted to push upwards through the soil than any dicotyledonous type; and that the bulbous plant seems in many respects the most highly specialized form of geophyte, its squat axis and pointed leaves, with broad sheathing base, being clearly adaptations to geophilous life.

In *M. excelsum* the leaf is pointed, often sharply so, especially in very young plants. There is always a sheath to the petiole, which entirely covers the young bud or young leaf, and is clearly a protective organ. In *P. Endlicheri* the leaves are more pointed in the young plant than in the old; but here the epidermis is of several layers, and stores water.

Hypocotyl.

Although details of transition in the hypocotyl are not rigid in the *Piperaceae*, they may still be of value. A similar type of structure has been found by different investigators in the *Ranunculaceae*, generally acknowledged to be primitive; in the *Labiatae*, *Centrospermae;* in all examined *Papaveraceae*, *Capparidaceae*, *Resedaceae*, *Cruciferae;* in *Pinus maritima;* and in many Monocotyledons. The same may perhaps in time be shown for further orders. Is it not possible, then, that the hypocotyledonary structure may be of phylogenetic value in showing a line of connection, or it may be common ancestry, for Monocotyledons and Dicotyledons?

It would seem, then, that *Macropiper* is a primitive form; *Peperomia* an advance with reduction; while Monocotyledons may have arisen as modifications and reductions of the dicotyledonous type, as more specialized forms, though earlier in time, perhaps, than the *Piperaceae*. The course of advance is, however, still shown by the relation of *Peperomia* to *Piper*, where the reductions arising in the former in response to environment are all in the direction of Monocotyledons, the monocotyledonous type most closely resembled being the *Araceae*.

In the specialization and reduction of *Peperomia* we see tendencies which have become firmly established in Monocotyledons.

Art. XXXVII.—*Observations on* Salicornia australis.

By Miss F. W. Cooke, M.A.

Communicated by Professor H. B. Kirk.

[*Read before the Wellington Philosophical Society, 9th August, 1911.*]

Introduction.

Salicornia australis is a small halophyte which grows abundantly in New Zealand, Tasmania, and Australia, along the sea-shores, and especially at the mouths of tidal rivers.

The genus consists of about eight species, found on most temperate and tropical shores, and occasionally in saline places inland (5).

"In central and northern Europe the first settler in littoral swamps is *Salicornia herbacea*, a succulent herb, and by the Mediterranean shrubby species of *Salicornia* (*S. fruticosa*, *S. macrostachya*, *S. sarmentosa*) occur in such habitats" (4, *c*).

I append notes under two headings—(1) Plant-habits; (2) Structure.

(1.) Plant-habits.

From April to June underneath the plants of *S. australis* are seen a large number of seedlings in which the plumule has made no appearance. Seedlings were only found where the plant was growing in the sand. (For the development of seedlings, see fig. 1.)

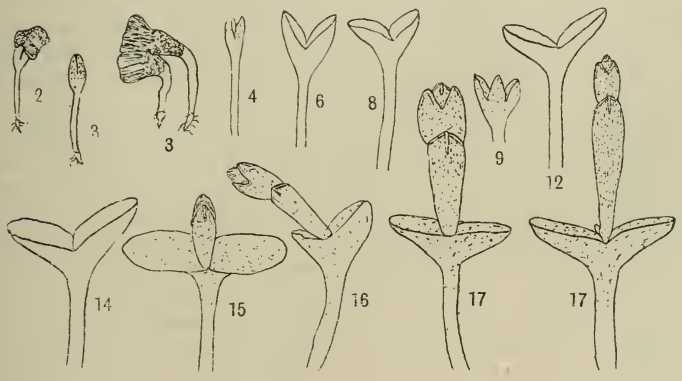

Fig. 1.—Seedlings of *Salicornia* grown in laboratory. (The numbers 2, 3, &c., denote the age of the plant in weeks. The one numbered 9 has three cotyledons.)

In autumn many plants in exposed positions die down and appear to be dead, but sprout up again from the base in July and August. In other plants the branches have a withered appearance, but from them fresh branches arise, so that the plant remains green. When the coast is rocky *S. australis* is found nearer the sea than any other vegetation. The conditions for life for these plants growing on rocks seem almost impossible, for there appears to be neither soil nor water, except from the sea. Plants

growing on low rocks washed by the sea are found on the tops of them, the action of the waves being too strong for them to get a footing at the base.

These plants have a stellate appearance, owing to the complete drying-up of old branches, the new ones all arising from the base. The roots are closely pressed against the rocks, and are matted together to collect any particles of soil.

The stems of many plants growing on loose shingle are long, thick, and woody, and are continued some distance below the surface, giving rise at the nodes to thick, long, adventitious roots.

A curious feature is shown in some stems, especially in those on which an inflorescence has been borne. The internode nearest the stem is withered and brown, several adjoining it are green and succulent, then again there are several brown and withered internodes, then either the succulent apex or the withered remains of the inflorescence (see fig. 9, *a*).

Plants growing on rocks almost in the sea become red, and wither very soon. The more exposed and drier, both physically and physiologically, a situation is, the more is the plant inclined to turn red.

Colouring always begins in the internode at the base of a branch, and proceeds upwards to the apex. The internode does not long remain coloured, but soon turns brown; thus there are never more than two or three internodes on the same branch coloured at the same time. It would seem that the plant turning red is an indication that the chlorenchyma is about to disappear. This is further borne out by the fact that the cotyledons of the seedlings growing on a small salt meadow at Paremata turn red before withering. That plants that die down early do not usually turn red shows that the withering is not necessarily preceded by the plant turning red. The red colouring is dissolved in the cell-sap, which gives an acid reaction. It is therefore probably anthocyanin. It is purple in reflected and red in transmitted light.

At Oriental Bay *S. australis* grows on cliffs 40 ft. above the sea-level, and with it large quantities of *Mesembryanthemum australe* and *Aciphylla squarrosa*. It also grows at the edge of the water, but is not immersed even at high tide, although in some other places it is.

At Napier the salt meadow covered with *S. australis* and plants mentioned above extends for several miles. This is one of the few extensive salt meadows in New Zealand. Most of the meadow is in the process of draining, so that each year it becomes drier. The whole meadow in autumn has a reddish tinge. The finest specimens I found at the edge of a lagoon which receives each day fresh supplies of salt, and is sheltered by a shingle-bank. The branches remain succulent for twelve months, and secondary wood is well developed in them while still succulent. They are duller in colour owing to a coating of wax, which serves to check transpiration. These plants contain much salt, and remain succulent for a long time when picked, showing that transpiration is greatly restricted, and that the water tissue has not given up its water to the atmosphere, but to the green tissues.

At Plimmerton, along the railway embankment, *Salicornia* forms a thick mat several feet wide and extending for some 50 yards. In some places the plants are very shrubby.

Salicornia australis is a frutescent or shrubby perennial. The stems are upright or procumbent; the usual height is 4–8 in. In a sheltered position at the edge of a lagoon the plants are $1\frac{1}{2}$–2 ft. in height, and the

branches are very long and thick. Sometimes when the stems are procumbent they are as much as 3 ft. long, and give off adventitious roots at the nodes. Short procumbent branches often become very thick and woody, being sometimes over $\frac{1}{2}$ in. in diameter. The young branches are cylindrical, green, and succulent, owing to the succulent leaves and leaf-bases which surround them.

The branching is opposite. In some plants the branches appear to be given off from the main axis, just below the insertion of a branch. These are, in the cases I examined, branches given off from the lowest node of that branch, the node being almost indistinguishable. Sometimes two branches arise together, and are surrounded by leaves (with only slightly developed bases), in the form of a spiral (see fig. 9, *c*).

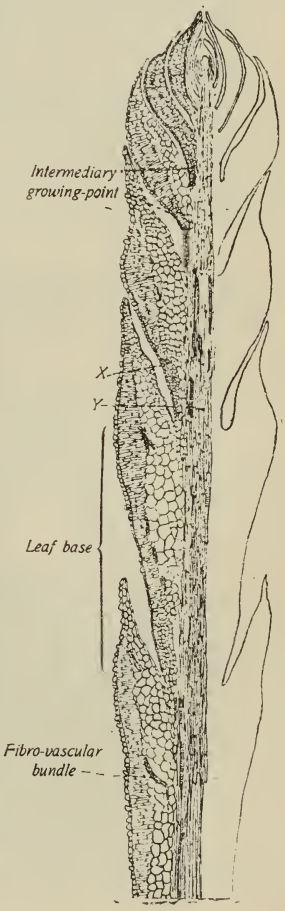

Fig. 2.—Longitudinal section of bud, ×16.

(2.) Structure.

Leaves.

Thomson, Cheeseman, Laing and Blackwell, and Miss Cross, all following Sir Joseph Hooker, describe *Salicornia australis* as "leafless," but I find that as long as green tissue remains on the plant leaves persist, and are short and connate—the free portions like decussate scales. At the apex they are only a few cells in thickness, but lower down abundant water tissue is present. The veins are not visible till a section is made. It is the greatly developed leaf-base which forms the "cortex" referred to by writers on *Salicornia*.

A longitudinal section of the growing-point shows an apical cone surrounded by leaves. Those near the apex have the base only slightly enlarged. Apical growth of the leaves soon ceases, and intercalary growth takes place at the base, as in the majority of leaves. This is recognizable by the fact that all the mitotic nuclei are there. The cells containing these nuclei are small and isodiametrical in shape (fig. 3, *b*). In leaves further down the stem the mitotic nuclei are still observable at the base. Thus this intercalary growing-point proceeds downwards, and gives rise to all the chlorenchyma, as well as all the water tissue of the leaf-base.

Running down the middle of the dorsal surface of the leaf is a white line, due to the absence of chlorophyll in the underlying tissue. The lower termination of the line marks off the free portion of the leaf from the beginning of the leaf-base. As each whorl of leaves overlaps the bases of the whorl above, the stem is never visible till the leaves have fallen.

The dorsal surface of the leaf is concave, the ventral convex. The leaf-margins are colourless, since, being only two cells in width, there is no palisade tissue developed between the dorsal and ventral epidermis.

The vascular system is well developed. I found no bundle-sheath present.

The following references show that the structure of the so-called cortex is constant throughout the genus :—

Ganong (3, *b*) describes *Salicornia herbacea* as having "a branching, succulent, practically leafless stem . . . possessing a compact stele (with cortical system of bundles replacing those of abandoned leaves), thick water-storing cortex."

Warming (2) says that in *Salicornia ambigua* the leaves stand out like collars round the older parts of the branches, which are shrivelled and thin, and in structure it differs little from *Salicornia herbacea*, described by De Bary.

De Bary (1, *b*) says *Salicornia herbacea* has chlorophyll tissue in palisade form in the cortex of the stem, and has short scaly leaves arranged in decussate pairs.

Reasons for calling Leaf-base what appears to be and has been described as "Cortex."

1. The vascular-bundle system in the cortex-like portion resembles that of a leaf. The leaf-trace divides, the middle branch behaving normally; the two lateral branches are directed upwards for a short distance,

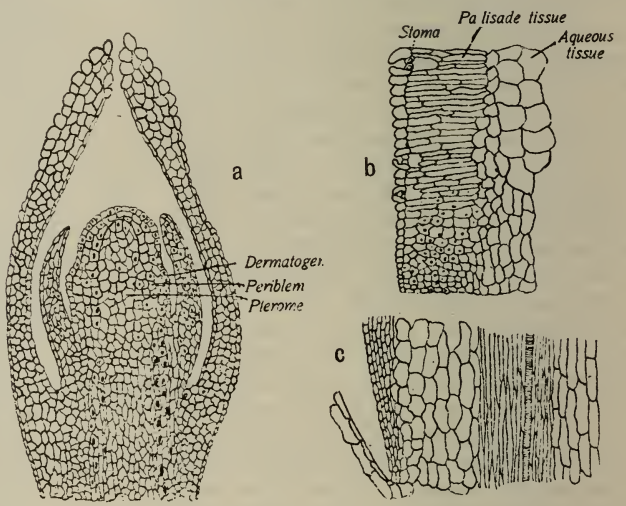

Fig. 3.—*a*, Longitudinal section of growing-point; *b*, *c*, x and y of fig. 2 under higher power.

and then run downwards in the aqueous tissue, anastomosing freely, and forming a network. This position of the vascular bundles is comparable to that in the basal portion of peltate leaves.

2. Except for the median branch, the network has no connection with the stem.

3. The bundles end blindly in mesophyll.

4. There is no difference between the palisade-cells in the leaf and leaf-base, and there is no break in continuity, they being developed in both on the ventral side.

5. The water tissue of the leaf-base (cortex) is in all parts similar to the mesophyll of the leaf, when this does not consist of palisade-cells.

6. Below what I regard as the leaf-base the stem loses its palisade tissue (see fig. 3, *c*). This is a very short portion of each internode, just the part covered by the leaves of the next node below.

7. A longitudinal section through the growing-point shows the leaf-base of the usual kind, with a very extensive growing-point (see fig. 2).

Cross-section of the internode before leaf-base disappears shows :—

(1.) Epidermis, a single layer of cells, the outer walls of which have developed a cuticle.

(2.) Palisade parenchyma and scattered tracheides.

(3.) Aqueous tissue, the internal limit of which is the endodermis.

(4.) Portions of fibro-vascular bundles scattered about in the aqueous tissue. These I regard as the vascular bundles of the leaf-bases.

(5.) Central cylinder or stele with a well-marked pericycle. This is the only portion in this section which can be called "stem." In this are embedded the collateral fibro-vascular bundles, which in this section are seven in number.

Cross-section of stem below the leaf-base shows :—

(1.) A thin-walled epidermis of cells much smaller than those of the leaf.

(2.) Hypodermis, two cells deep.

(3.) Cortex of thin-walled parenchymatous cells resembling those of water tissue, only much smaller. Chloroplasts are few in number in comparison with those of the chlorenchyma in the leaf and leaf-base.

(4.) Central cylinder.

There is no cuticle, no stomata, no palisade tissue, no scattered tracheides, and no fibro-vascular bundles except in central cylinder.

Epidermis of Leaf and Leaf-base.

The epidermis consists of a single layer of thin-walled cells whose outer walls present cuticular thickenings. The cells of the dorsal differ considerably from those of the ventral side of the leaf, the radial walls being short and the tangential long. The outer wall is quite flat, and there are no stomata. On the ventral side a longitudinal section shows the epidermal cells have the vertical diameter about the width of the radial, and the outer walls are raised into small papillae. Surface view shows that the cells are—(*a*) hexagonal, with sharp corners ; (*b*) elongated transversely. This transverse extension, according to De Bary (1, *d*), occurs only in the leaves of several plants or in the stems when palisade tissue is developed in the cortex. It occurs also in the leaves and leaf-bases of *Salicornia australis*. The nucleus of epidermal cell is large, and when treated with alcohol turns yellow and becomes very obvious.

As usual in the case of the epidermal cells, there are no chloroplasts except in the guard-cells of the stomata. If, however, the plant is grown under a bell jar, and is watered often, chloroplasts, few in number, may be found in the epidermal cells. Under these conditions the epidermal cells are not elongated transversely, and are wavy in outline.

The cells of the epidermis of the hypocotyl are very much longer than they are wide, but the elongation this time is longitudinal. Cross-section of hypocotyl shows a number of the epidermal cells dividing periclinally (see fig. 4, *e*).

Stomata.—Stomata are numerous on the ventral surface, but absent on the dorsal. Development, as far as I have made out, takes place in the usual way, and the first stomata are formed about the 4th leaf from the apex. The guard-cells are long, and are comparatively narrow. Their walls are thick, and at the top and bottom the thickened portion of the wall bounding the pore projects in the form of a ridge. Midway between these ridges the walls are not thickened, and when turgid jut out into the pore, and thus facilitate its closing. The guard-cells are half the epidermal cells in height, and are sunk beneath the epidermis, the inner walls being in the same plane as the inner walls of the epidermal cells.

Warming (2) and Miss Cross (7) describe stomata as not being sunk. I found that they were sunk in every case, except in the cotyledons, which are not referred to by either of these writers.

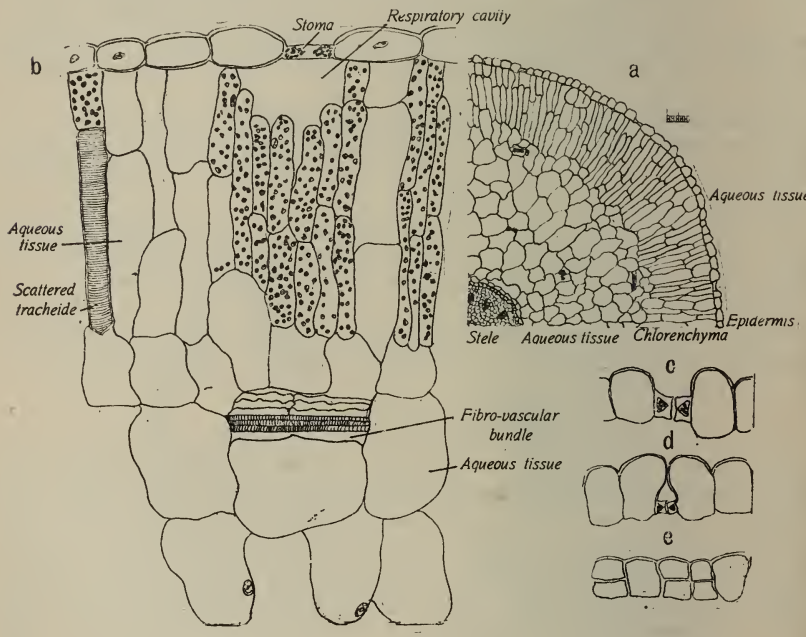

Fig. 4.—*a*, Transverse section of stem surrounded by leaf and leaf-bases; *b*, transverse section of tracheides; *c*, longitudinal section of stoma at 9.30 a.m.; *d*, longitudinal section of stoma at 6 p.m.; *e*, transverse section of epidermis of cotyledon, showing cells dividing.

If a longitudinal section of leaf or leaf-base is taken at the end of the day, after transpiration has been going on freely, it is seen that the cells which abut on the guard-cells curve over them. If a section is taken late that night or early the next morning, these cells are no longer curved. Thus when turgidity is reduced the cells curve over the stoma, and the amount of transpiration is diminished (see fig. 4, *c*, *d*).

The stomata are situated above the palisade tissue. This is not usual in ordinary leaves, but occurs in plants having much the same structure as *Salicornia*. The guard-cells are at right angles to the axis of the stem.

Aqueous Tissue.—The cells are large, thin-walled, and colourless, and have a delicate lining of protoplasm. The nucleus is large and well marked, and the remainder of the cell is filled with water.

In a plant whose cells have remained succulent all the winter the water has much salt dissolved in it, and chloroplasts are found in the protoplasm. Starch-grains are present, and are often aggregated round the periphery of the nucleus.

In plants grown under a bell jar through the winter all the aqueous tissue contained chloroplasts. It may be inferred that the aqueous tissue is modified chlorenchymatous tissue.

Palisade tissue is developed on the ventral side of the leaf and leaf-base. The tissue is two or three cells deep. The cells are thin-walled, elongated at right angles to the epidermis, have rounded ends, and are separated by numerous small intercellular spaces. Large intercellular spaces, respiratory cavities, lie beneath the stomata.

Palisade-cells contain numerous chloroplasts, and, with the exception of the guard-cells and aqueous tissue in the case mentioned above, they are the only cells containing chlorophyll.

The chlorenchyma is interrupted at intervals by small patches of water tissue two or three cells wide, and in these patches are sometimes found the scattered tracheides.

Palisade tissue is not found in the stem itself.

A longitudinal section of the growing-point shows palisade tissue well developed about the 6th or 8th leaf down. Further down it is to be seen developing from an intercalary growing-point.

Scattered Tracheides.—These are present in the palisade tissue of both leaf and leaf-base. Their length is perpendicular to the epidermis, but they do not reach out to it, ending one short cell from it. There are a number of these short palisade-cells, but they do not form a layer. The other end of the tracheides abuts on the water tissue, but there is no connection with the vascular bundles there. According to De Bary (1, *c*), these tracheides occur close to one of the numerous air-cavities of the stomata. I also found them in the water-containing palisade tissue in the leaf, and in such cases they were two or three cells from the epidermis. The tracheides are cylindrical in shape, the ends being sometimes oblique. The walls are thicker than those of the adjoining cells. Thickening takes the form of a close fine delicate spiral. The function is that of air-storage. Similar air-storing tracheides are referred to in *Salicornia herbacea* by Ganong (3, *a*), and by Duval Jouve in *Salicornia emerici* (see fig. 4, *a*).

Apical Growth.—A longitudinal section through the apex of the stem shows an apical cone surrounded by leaves. It appeared as if the opposite character of the leaves was a secondary consideration, since the leaves were at the very apex alternate. This was probably due to the twisting of the young stem, since cross-sections did not bear out this theory.

The meristem at the apex is differentiated into three layers—(1) the outer dermatogen, a layer of cells all the same size with mitotic nuclei; (2) periblem, two or three cells wide; (3) plerome (see fig. 3, *a*).

There is a slight bulging in the apical cone where the next leaf will arise. The leaves overarching the growing-point are wider at the apex; the other leaves taper to a point (see fig. 2).

There is a depression in the leaves on the lower side, and in this depression the apex of the leaf next below lodges.

Stomata do not appear to be formed till the 4th leaf down.

There is a clear indication that the leaf-trace bundles are sent inwards.

The Root.—The stele is diarch; the bundles of phloem are quite distinct and easily distinguished from the xylem. As in the majority of roots, the medulla becomes obliterated.

In old roots the structure resembles that of the stems, in that secondary xylem and phloem are developed from an extra-fascicular cambium. It differs in that phloem islands in the root are slightly larger than those in the stem, and the fibrous cells round them have thinner walls. The distinction between one season's growth and the next is more apparent.

A cross-section of the hypocotyl shows two groups of xylem which converge to form, in the root, the plate, on each side of which is the phloem group (see fig. 5, *a*).

The development of the root takes place as usual.

Seedlings have numerous long delicate hairs, the outline of which is often crinkled and wavy. They present a curious resemblance to fungal

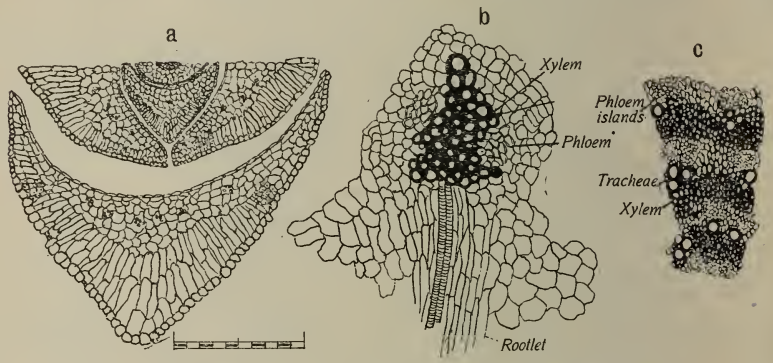

Fig. 5.—*a*, Transverse section of root of an old plant; *b*, transverse section of young branch, near tip; *c*, transverse section of part of internal structure of root of a seedling.

hyphae, and portions of them are often swollen, especially the tip. Some of them are as much as 2 mm. in length, while the root is only 0·25 mm. in diameter. They extend along the root, from just behind the growing-point to the base of the hypocotyl.

Cotyledons.—Stomata occur on the upper and lower surfaces, and are placed as in leaf and leaf-base, but are not sunk beneath the epidermis. The guard-cells are short and wide, so that in surface view the stomata appear circular.

Epidermis.—Surface view of epidermal cells shows that they are wavy in outline. In a cross-section the radial walls are shorter than the tangential, and the outer walls are flat. Seedlings grown in a greenhouse showed chloroplasts, few in number, in some of the epidermal cells.

In cotyledons palisade tissue is developed beneath the upper epidermis only.

Secondary Growth.

Stems of *Salicornia* increase greatly in thickness owing to secondary growth, some of the older ones being $\frac{1}{2}$ in. in diameter.

The cambium in the original collateral fibro-vascular bundles soon becomes exhausted, causing the secondary phloem and xylem to have an unusual origin. As a rule, with the exceptions noted below, interfascicular cambium is not formed.

A cross-section of a branch six months old shows just outside the phloem a layer of cells divided usually by tangential and occasionally by radial walls. Thus a complete extra-fascicular cambium ring is formed (see fig. 6). This has been recorded by De Bary for *Salicornia herbacea* (1, *e*). The xylem formed from this cambium consists of thick-walled fibrous cells, among which are situated, in irregular rings, the vessels, with very large lumens. The phloem consists of thin-walled cells, forming, as usual, a cylinder outside the cambium. No sieve-tubes could be detected among these cells, which in *Salicornia australis* always contain chlorophyll, and are densely packed with starch-grains. Some of these cells disintegrate, those remaining being arranged in radial rows, between which are large intercellular spaces.

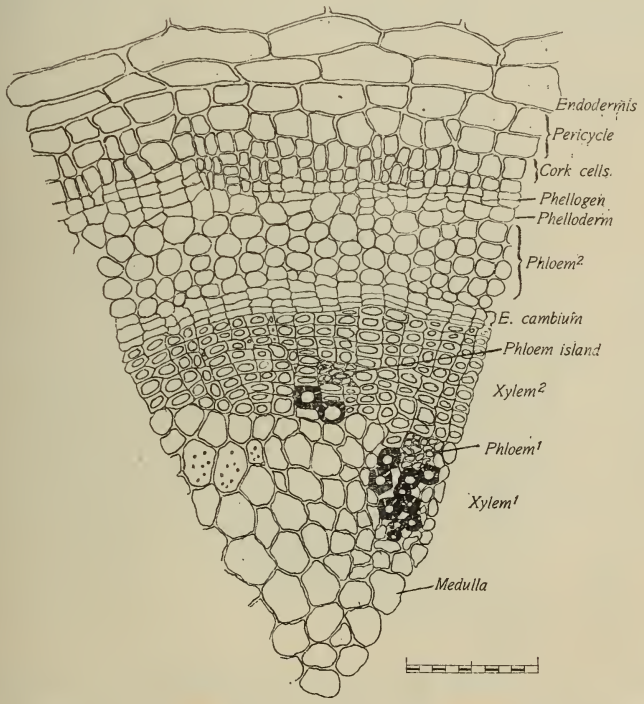

Fig. 6.—Transverse section of stem, showing extra-fascicular cambium ring (E. cambium).

In addition to the phloem cylinder, there are phloem islands scattered about in the fibrous cells of the xylem, in each case lying just outside the large vessels, from which they are separated by only a few fibrous cells.

A theory which might account for these phloem islands is this: The formation of the large vessels consumes time; while these are forming, the cells each side of the group of vessels, growing more quickly, grow over, enclosing a small patch of cambium. This gives rise to the phloem and several small fibrous cells, the latter separating the phloem from the vessels.

The phloem islands consist of thin-walled cells, which show great uniformity in length. When stained with saffranin they are easily distinguished, since they turn an orange colour, the cells of the xylem

turning red. Particles in the cells of the phloem islands exhibit Brownian movements. The phloem islands were at first thought to be either phloem or xylem parenchyma cells. Careful investigation showed that in some cases undoubted sieve-tubes are present, although none were found in the phloem cylinder. The walls of the sieve-tubes, as usual, are thin and colourless, and the sieve-plates slightly oblique. I could not with certainty observe any pits in the sieve-plates, or any callus.

The Tracheae.—In this plant, as usual, the protoxylem vessels are spiral, the spiral being here from right to left. The xylem of the leaf-traces consists entirely of spiral vessels. In addition to these, there are the large vessels mentioned above. In many cases they are observable in the course of formation. They usually occur in groups of two or three, but there may be as many as six. They are the only cells of the xylem which do not

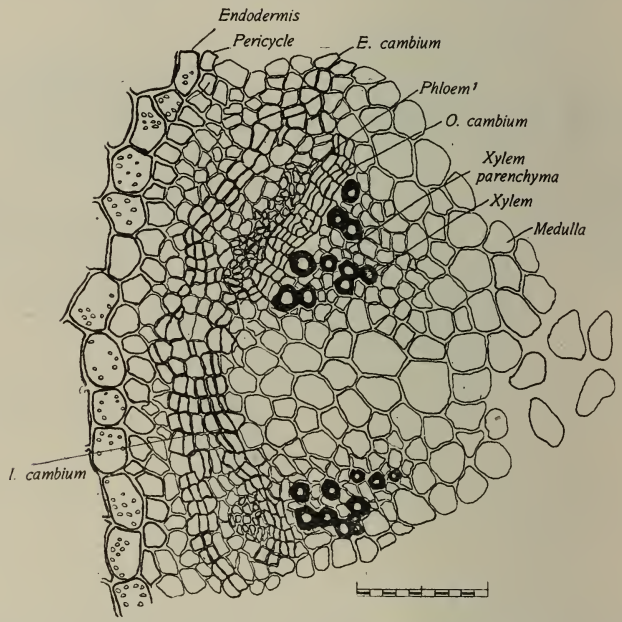

Fig. 7.—Transverse section of stem, showing extra-fascicular, interfascicular, and original cambium.

contain starch. Their walls are greatly thickened and pitted, the pits differing from the simple pits of fibrous cells, although in the walls of the vessels bordering the fibrous cells they are simple. The pits differ from ordinary bordered pits in that their walls, instead of being dome-shaped, are perpendicular to the middle lamella (see fig. 8, *a*, *b*).

Fibrous Cells.—In this plant the secondary wood consists chiefly of fibrous cells. These have greatly thickened walls, and resemble woody fibres more or less closely in form. There is no stratification or striation observable. A few are septate. The fibrous cells always contain abundance of starch-grains, which are large and closely packed. In places a few chloroplasts are present. The cells are all about the same length.

The nuclei are large, those of the adjoining cells being in a straight line, showing there has been practically no displacement of the cells due

to elongation. There are numerous pits, simple, both in radial and oblique walls.

As the cells always remain living, there is no differentiation into heart and sap wood.

No sclerenchymatous fibres were found anywhere.

Medullary Rays.—Primary medullary rays are not continued through the secondary wood, and, as a rule, no clearly distinguished secondary medullary rays are formed; nor is there any necessity for them, seeing that most of the xylem-cells are living and are connected by pits. Occasionally I found a distinct medullary ray, the cells of which were elongated radially, being three times as long as they were broad, and narrower than the fibrous cells. There occur also a number of bands of cells one or two wide, the cells having then radial diameters slightly longer than the tangential. These resemble the medullary rays in *Mahonia* given by Schleiden, where they are very thick-walled, and scarcely to be distinguished from the fibrous cells of the wood. In *Salicornia* they are packed with starch-grains.

The result of this slight development of medullary rays is that they are not observable in longitudinal section.

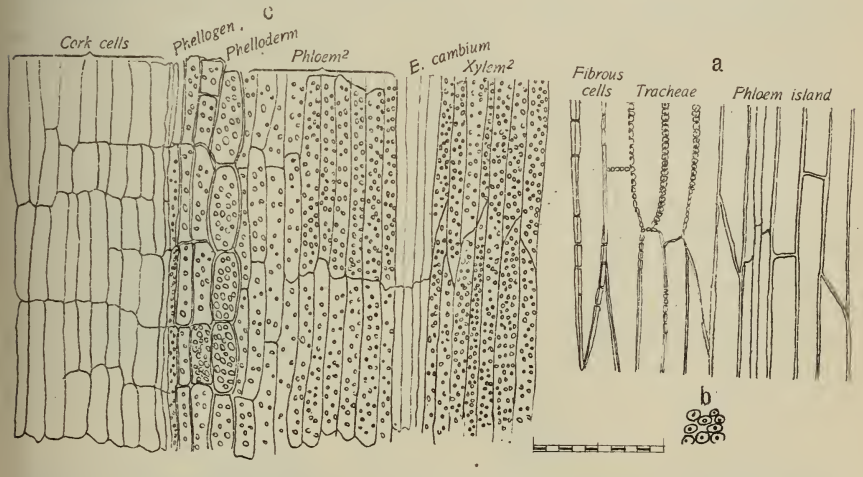

Fig. 8.—*a*, Longitudinal section of stem of secondary growth; *b*, pits in trachea; *c*, longitudinal section showing periderm.

A cross-section of a branch which has remained succulent all the winter shows not only the fascicular cambium dividing and increasing in size, but cells are dividing between the bundles to form interfascicular cambium (fig. 7). When the bundles are close to each other the dividing cells reach right across, but when far apart the line of the dividing cells curves outwards and joins on to the extra-fasicular cambium, forming a complete ring round the phloem.

The interfasicular cambium does not long remain functional, and the majority of secondary tissues are formed from the extra-fascicular cambium as usual.

The Formation of Cork.—As winter advances, as a rule, all the branches formed in spring assume a different appearance. The succulent tissue becomes withered and turns brown, the free portion of the leaves of each internode surrounding the base of the internode above like a collar. This

brown portion finally falls off, or, if the plant is at the water's edge, is soon washed off, and the branches appear green again. They are, however, much smaller, having lost all palisade and aqueous tissue. The green colour is due to chloroplasts in the phelloderm and the phloem cylinder. Chloroplasts are also present, although to a less extent, in the fibrous cells of the wood and in the outer portion of the medulla. The development of chlorophyll corresponds to that in several desert-plants mentioned by Austin (9) (see fig. 8, *c*).

This withering of tissue is due to the formation of cork. The inner layer of pericycle, which is now several cells thick, gives rise to phellogen. Cork tissue and phelloderm are formed in the usual way. The phelloderm in this plant even more than usual shows great uniformity in the length of cells. Chloroplasts are present, and starch, which is never found to be exhausted. The granules are larger than those of the phloem cylinder.

Flowers.

Salicornia australis flowers from December to March. The flowers are wind-pollinated. All the branches may be fertile, and bear small

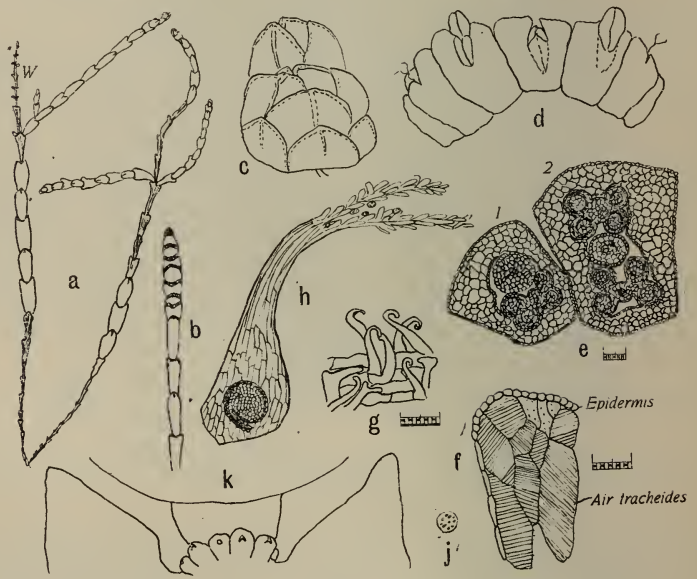

Fig. 9.—*a*, Branch showing withered inflorescence, two-fifths natural size; *b*, flowering-branch, two-fifths natural size; *c*, bud, × 3; *d*, flowers, × 6; *e*, transverse section of flower—(1) with one stamen, (2) with two; *f*, persistent perianth; *g*, hooked hairs on testa; *h*, pistil; *j*, pollen-grain; *k*, longitudinal section of flowering-branch taken in July, five months before flowers are mature.

insignificant flowers at their apex; these flowers are placed side by side in the axils of the leaves, and form an almost complete ring. The leaf-bases in the flowering-branches are developed only to a comparatively small extent.

The number of flowers in each axil, as a rule, varies from five to ten; occasionally there are as many as sixteen, and then they form a double row round the branch.

The flowering-branches are thicker than the ordinary branches, and do not taper to a point like those of *Salicornia herbacea*, shown by Schimper (4, *a*).

A very young flowering-shoot does not differ in appearance from an ordinary one. When the internodes of the ordinary branch lengthen, the difference becomes apparent, since those of the flowering-branch always remain short.

If a longitudinal section is made (see fig. 9, *k*) the flowers are seen sessile in the axils of the leaves. The section was made five months before the plant flowers, and even then the perianth was little different from that of a mature flower.

Flowers are hermaphrodite or polygamous. Several whorls of flowers were examined in order to find some regular arrangement, but none was observable.

An examination of a large number of flowers shows that the stamens are usually two in number, occasionally one, rarely wanting the pistil of one carpel.

The perianth is monochlamydeous, fleshy, broad, flat, and quadrangular at the top. The lobes, three in number, fit together, almost closing the mouth. On this quadrangular portion the epidermal cells are very thick-walled and isodiametrical, and there are a number of stomata. Beneath this lies a little chlorenchyma, and then the aqueous tissue. The flowers are narrower at the immersed base, and the epidermis of the perianth here is very thin-walled, and the cells are elongated longitudinally, as in the hypocotyl.

When the seed is ripe the fleshy perianth persists, the cell-contents disappear, and the cell-walls become thickened by regular bands which run in different directions in different cells (see fig. 9, *f*), and the cells are filled with air. This is evidently an adaptation for dispersal, for by means of this persistent perianth the seeds float on the top of the water for a long time. Seeds were placed in fresh water, and at the end of a week only 3 per cent. of them had sunk. The perianth remains attached to the cotyledons even when the seedling is several months old.

Androecium.

Stamens are perigynous, two or one, occasionally there is only one staminode. In the young flower the filament is short, but it is later elongated so that the stamen hangs out of the mouth. When there are two fertile stamens they are protruded successively. There are two large anther-lobes attached to the filament for about half their length. Development takes place as usual. Each lobe consists of two compartments when the anther is young, but when mature of one only. Dehiscence is by a longitudinal crack coinciding with the partition between the two pollen-sacs. The pollen-grains are developed in the usual way. Each has a thickened wall in which there are numerous round pits (see fig. 9, *j*).

Gynoecium.

Ovary is superior, of one carpel, and ovoid, containing one basal anatropous ovule.

Styles, two in number, are papillose, long and narrow, and tapering to a point.

Flower is protogynous, and the styles hang out of the mouth before the stamens.

Utricle is ovoid, consisting of a thin loose pericarp enclosing the seed. It is itself surrounded by the persistent perianth.

Testa is brown, coriaceous, and covered with hooked hairs of different shapes (see fig. 9, *g*). The inner coat of the seed is thin and membranous.

There is no endosperm.

Embryo has thick fleshy cotyledons, and an incumbent, terete, radicle.

Bibliography.

1. De Bary. "Comparative Anatomy of the Vegetative Organs of Phanerogams and Ferns," 1884—*a*, p. 45; *b*, p. 48; *c*, p. 226; *d*, p. 31; *e*, p. 591.
2. Warming. "Halofyt-Studier," pp. 215, 216.
3. Ganong. "The Vegetation of the Bay of Fundy Salt and Diked Marshes"—*a*, p. 357; *b*, p. 448.
4. Schimper. "Plant Geography"—*a*, p. 654; *b*, p, 182; *c*, p. 652.
5. Cheesman. "Manual of New Zealand Flora," p. 585.
6. Schleiden. "Principles of Botany."
7. Miss Cross. "Observations on some New Zealand Halophytes." Trans. N.Z. Inst., vol. 42, 1910, p. 563.
8. Kerner and Oliver. "The Natural History of Plants."
9. Austin. "The Topography of Chlorophyll Apparatus in Desert Plants."
10. Harshberger. "Comparative Leaf-structure of the Sand-dune Plants."
11. Pehr Olsson Seffer. "Hydrodynamic Factors influencing Sandy Seashores." "New Phytologist," vol. 8, 1909.
12. G. Hill. "Observations of the Osmotic Properties of Root Hairs of certain Salt Marsh Plants." "New Phytologist," Nos. 6 and 7, 1908.
13. Laing and Blackwell. "Plants of New Zealand."
14. Hooker. "Handbook of New Zealand Flora."
15. Hooker. "Students' Flora of the British Isles," p. 341.
16. Warming. "Systematic Botany"; translated by Potter.
17. Thomson. "Introductory Class-book of Botany."
18. Strasburgher. "Text-book of Botany."

Art. XXXVIII.—*On a Collection of* Mallophaga *from the Kermadecs.*

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Communicated by A. Hamilton.

[*Read before the Wellington Philosophical Society, 6th September, 1911.*]

The material which forms the subject of this paper was collected by the expedition of New Zealand naturalists which visited the Kermadec Islands in 1907–8 under the guidance of Messrs. Tom Iredale and W. R. B. Oliver. From the labels we judge that it was collected chiefly by Mr. W. L. Wallace. It was forwarded by Mr. Oliver to the Dominion Museum, Wellington, and the Curator of that institution, Mr. A. Hamilton, has been kind enough to place it in our hands for description.

The *Mallophaga* collected comprise thirteen species from five bird hosts, and one species from a mammal, the introduced domestic goat. To these we have added two species taken by one of us from a skin of *Oestrelata neglecta* Schl., forwarded by Mr. Oliver to Mr. A. F. Basset Hull, of Sydney. As Mr. Iredale's notes (1910) mention about thirty species of birds observed on the group, it is obvious that nothing like a complete collection of the Mallophagan fauna was obtained.

Of the sixteen forms reviewed, we have described six as new species, one as a new variety of a known form, eight have been ascribed to already known species, and consideration of one species has been deferred.

List of Hosts, with Parasites.

Pelagodroma marina Lath.
- *Ancistrona procellariae* Westw.
- *Lipeurus languidus* Kell. & Kuwana.
- *Lipeurus exiguus* Kell. & Kuwana.

Oestrelata neglecta Schl.
- *Philopterus fuscoclypeatus* nobis.
- *Lipeurus diversus* Kellogg var. *excavatus* nobis.
- *Lipeurus kermadecensis* nobis.

Charadrius dominicus Müll.
- *Philopterus wallacei* nobis.
- *Degeeriella oraria* Kellogg.
- *Colpocephalum timidum* Kellogg.

Numenius variegatus Scop.
- *Philopterus armatus* nobis.
- *Philopterus numeniicola* nobis.
- *Degeeriella oliveri* nobis.

Sturnus vulgaris Linn.
- *Philopterus leontodon* Nitzsch.
- *Degeeriella nebulosa* Burmeister.
- *Menopon* sp.

Capra hircus Linn.
- *Trichodectes climax* Nitzsch.

LIOTHEIDAE.

Menopon sp.

Among the parasites collected from the European starling (*Sturnus vulgaris* Linn.) are specimens of a *Menopon* similar to some which we have ourselves collected from the same host in New South Wales, but which do not agree with any *Menopon* described from the starling that we can trace. As it seems somewhat improbable that what is apparently a common parasite of an extremely common bird should have eluded observation, we have deferred consideration of this species until we are dealing with our New South Wales material, in order to allow of a further search.

Colpocephalum timidum Kellogg (1896, p. 145, pl. 12, fig. 6).

One male and a few females from *Charadrius dominicus* Müll. This species has previously been taken by Kellogg from the same host in Kansas, U.S.A., and also from *Squatarola squatarola* Linn. from California (1899, p. 112). Kellogg gives the breadth of the female as 0·37 mm., which is evidently a misprint, as our specimens measure from 0·58 mm. to 0·64 mm.

The male, which is apparently undescribed, resembles the female, with the exception that the angles of the abdominal segments project a little more prominently, and the last segment is more bluntly rounded. Length, 1·65 mm.; breadth, 0·52 mm.

Ancistrona procellariae Westwood (1874, p. 197).

Syn., *Ancistrona gigas* Piaget (1885, p. 117), Kellogg (1896, p. 150, and 1899, p. 116).

One individual referable to the genus *Ancistrona* was found upon *Pelagodroma marina*. Two species have been described under this genus; the type, *A. procellariae*, by Westwood from a *Daption capense* presented by Messrs. R. Brown and Baird to the Hope Museum, Oxford. No locality is given, but it may be assumed that the bird in question formed part of an Antarctic collection, as Baird described parasites from Antarctica. Piaget described a second species, *A. gigas*, from a *Procellaria* collected on the Barendts north polar expedition. We have a separate copy of the paper containing his original description, but it bears no date, and no indication as to the periodical in which it originally appeared, and we have been unable to trace a reference to it in any bibliography of the group accessible to us. The date may be fixed roughly as 1883–84, as the paper in question follows immediately on another by the same author, criticizing the "Die Mallophagen" of Taschenberg, which was published in 1882. The original description is, however, reproduced verbatim by Piaget in his Supplement (1885, p. 117), and this reference is given by Kellogg (1896, p. 150; 1899, p. 116; 1908, p. 75) for the original account.

Piaget gives a detailed description of his type, but does not particularize any characters by which it differs from *A. procellariae* Westwood, except its larger size. His own words are, "L'espèce se rapproche génériquement de l' *A. procellariae* de M. Westwood, mais en diffère spécifiquement, surtout par les dimensions. Seulement la description donnée par le savant entomologue est trop sommaire pour permettre une comparaison détaillée."

Westwood gives the length of his species as $2\frac{1}{2}$ lines (roughly, $5\frac{1}{4}$ mm.), while Piaget gives his as 6 mm., so that the difference in size is only $\frac{3}{4}$ mm.

in a length of 6 mm., which hardly justifies an assumption of specific difference. It seems to us possible that Piaget has read Westwood's measurement as millimetres, not lines.

Westwood's description is short, and his figure poor, but there is nothing in either to indicate a specific difference between the forms described by him and by Piaget. The poorness of his figure may be accounted for by the fact that *Ancistrona* is very difficult to view satisfactorily under a microscope, the variations in thickness being comparatively so large. As a matter of fact, Piaget has fallen into error in his figure of the ventral parts of the head, for he figures as a posterior production of the hind-head what is really an anterior intercoxal production of the prothorax.

Kellogg (1896, p. 50; 1899, p. 116) obtained specimens of an *Ancistrona* from various petrels on the Californian coast of the North Pacific, which he has referred to *A. gigas* Piaget.

Finally, the individual we have under review comes from the South Pacific, and on that account might well be expected to agree with Westwood's species rather than Piaget's, if the two were distinct. We find it agrees with Piaget's description of *A. gigas* in all details except size, as it measures only 4 mm.

We conclude from the foregoing that there is only one species so far known in the genus, and we rank *A. gigas* Piaget as a synonym of *A. procellariae* Westwood.

Philopteridae.

Lipeurus kermadecensis n. sp.

Description of Female.—Head subconical, elongate, narrower in front; anterior portion of clypeus obtusely rounded and transparent; lateral margins of forehead strongly chitinized, with narrow transverse interruptions to roots of marginal hairs, and continued as antennal bands behind antennary fossa, ending internal to the eye; temples rounded, not distinctly wider than at trabecular angles, without distinct bands; occiput roundly emarginate; all the hind-head evenly chitinized, with transparent interspaces from the antennary fossae meeting in the middle line at about half the distance between the line of the antennae and the occiput, and continuing to apex of occipital emargination; from each branch a lateral interspace given off, passing posteriorly parallel with temporal margins to occiput; trabeculae practically absent; antennae with 1st and 2nd segments equal and longest, 5th next in size, 3rd and 4th smaller and about equal; 3 marginal hairs on side of forehead, corresponding to interruptions through the lateral band; between the anterior pair a dorsal and a ventral hair, internal to lateral band; small hair in front of trabecular angle, and one at angle; 4 or 5 small hairs round temporal lobe, that at temporal angle more prominent than the others; 2 pairs of hairs on dorsal surface of forehead.

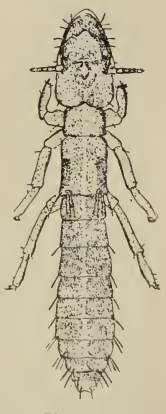

Fig. 1.

Lipeurus kermadecensis. ♀.

Prothorax approximately rectangular, broader than long, evenly chitinized, slightly darker at antero-lateral margins, with a median interruption. Metathorax more than twice as long as prothorax, approximately rectangular, anterior angles slightly truncated, lateral margins somewhat

compressed; middle of posterior margin projecting slightly on to abdomen; evenly chitinized, mid-lateral parts more deeply coloured; median interruption continuous with that of prothorax; a long hair at posterior angle, and inwards from it a group of 3 pustulated hairs.

Abdomen of 10 segments, narrow, elongate, sides subparallel; gradually increasing in width to 6th segment, then sharply tapering to 10th, which is slightly bilobed; all evenly chitinized, with median interruption as in thorax extending through 8 segments; 9th completely chitinized; 10th with chitinous lateral blotches; 2 pairs of small hairs on posterior margin of each segment, and a large pair of ventral hairs, one on each side of the mid-line; on 1st segment 6 other small hairs, 4 of which are near anterior border; one hair at posterior angle in segments 2 to 4, two in 5 and 6, three in 7th, one in 8th and 9th; on segments 9 and 10 a pair of dorsal hairs.

Length, 1·76 mm.; breadth, 0·28 mm. Head, 0·44 mm. by 0·28 mm.

Three females taken by one of us from a skin of *Oestrelata neglecta* Schl. forwarded to Mr. A. F. Basset Hull, of Sydney. This species approximates closely to *Lipeurus limitatus* Kellogg (1896, p. 124) from *Puffinus griseus* Gmel. from California, but differs in being little more than half the size, in the shape of the prothorax, in the median interruption of the abdomen being continuous through 8 segments and not 7 only, and in the disposition of the interruptions of the hind-head. The male is unknown, as is the male of *L. limitatus*, Kellogg also having collected females only.

Fig. 2.

Lipeurus diversus var. *excavatus*. ♀.

Lipeurus diversus var. excavatus var. nov.

This form is intermediate between *L. angusticeps* Piaget (1880, p. 306) and *L. diversus* Kellogg (1896, p. 123), approaching more closely to the latter. Our form differs from Kellogg's species in having distinct lateral bands on the margin of the clypeus, in front of the antennal bands; occipital blotches slightly different in arrangement; bands of prothorax produced more markedly on to metathorax, and not interrupted at the suture; hairs on posterior margin of metathorax slightly different in arrangement, the second hair from the angle being small, and not of almost equal length with the others; lateral bands of abdomen distinctly broader, each produced anteriorly into a concavity in posterior margin of that of preceding segment; this posterior margin with a clear diverticulum towards lateral margin, the exact relations being best seen in the figure. The sexual dimorphism agrees with that shown in Kellogg's figures of *L. diversus*, but as the one male at our disposal has lost his antennae we are unable to compare the males satisfactorily.

Several specimens from *Oestrelata neglecta* Schl. from Sunday Island. We have figured a female.

Lipeurus languidus Kellogg and Kuwana (1902, p. 475, pl. 29, fig. 8).

Two females and one male of this species were taken from *Pelagodroma marina* Lath. The species was originally described from Galapagos Island, where it was taken from *Oceanites gracilis* and *Procellaria tethys*, as well as on a number of other hosts to which it had obviously straggled.

Lipeurus exiguus Kellogg and Kuwana (1902, p. 479, pl. 30, fig. 2).

One female from *Pelagodroma marina* Lath. The species was originally described from *Oceanites gracilis* from Galapagos.

Degeeriella oliveri n. sp.

A few males and one female of this species were collected from *Numenius variegatus* Scop. The form resembles fairly closely *D. actophilus* of Kellogg and Chapman (1899, p. 78) from *Calidris arenaria* Linn. from California, and, in a less degree, *D. inaequalis* of Piaget (1880, p. 176) from *Numenius arquatus* Linn. from Europe; but differs markedly in detail from either. From both the forms mentioned our species differs in the proportionately greater length of the head in front of the antennae, and also in the relations of the chitinous framework of the clypeal parts. The signature does not extend across the width of the clypeus, as in Kellogg's figure of *D. actophilus*, and its rounded posterior angle projects strongly into a clear uncoloured space, which is thus not a transverse bar, but a more or less horseshoe-shaped clear area. Dorsal to the signature, the clypeal bands of either side are produced as a deeply sinuous structure crossing the anterior margin of the head.

Fig. 3.
Degeeriella oliveri ♂.

From *D. inaequalis*, to which it approximates in size, it is easily distinguishable from the fact that the sides of the abdomen are convexly subparallel to the 6th segment, and then taper somewhat to a broadly rounded 9th segment in the male, while Piaget's species has the abdomen much swollen at the 4th and 5th segments, and tapering considerably before and behind. Also, the last segment of the abdomen in the female is barely notched, and not markedly bifid, as figured by Piaget.

From *D. actophilus*, besides the differences in the head region already indicated, it may easily be distinguished by its greater size, 1·85 mm., as against 1·6 mm.

We figure the male, of which the measurements are: Length, 1·85 mm.; breadth, 0·37 mm.; head, 0·49 mm. by 0·3 mm. The female differs chiefly in the shape of the abdomen, the sides of the last two segments converging abruptly, and meeting almost at right angles, with a slight notch in the apex; and in the generally lighter colour of the transverse bands of the abdomen. It measures: Length, 1·88 mm.; breadth, 0·44 mm.

We have named this species in tribute to Mr. W. R. B. Oliver, one of the leaders of the expedition.

Degeeriella nebulosa Burmeister.

Nirmus nebulosus Burmeister, Denny (1842, p. 132, pl. 11, fig. 13).

A couple of individuals of this common parasite of the starling were obtained from *Sturnus vulgaris* Linn.

Piaget (1880, p. 155) wrongly credits Denny with being the author of this species.

Degeeriella oraria Kellogg.

Nirmus orarius Kellogg (1896, p. 104, pl. 5, fig. 5).

Two females which we have referred to the above species were taken upon *Charadrius dominicus* Müll. The species was described by Kellogg from a single female taken from the same host in Kansas, U.S.A., which would seem to have been immature.

Our specimen agrees in general with Kellogg's description, but has strong square blotches on the ventral surface of the abdomen, and small dark median blotches on segments 3–7 on the dorsal surface, neither of which are mentioned in Kellogg's description. In addition, a pair of median hairs is found on all the segments, and not only on segments 3–6, as figured; there are 5 hairs on either side of the metathorax, not 4; and the dimensions are somewhat greater, the length being 1·95 mm. as against 1·84 mm., and the breadth 0·47 mm. against 0·4 mm.

Philopterus leontodon Nitzsch (1818).

Docophorus leontodon Nitzsch, in Giebel (1874, p. 90, pl. 11, figs. 4, 7).

A solitary immature specimen of a *Philopterus* was taken from the introduced European starling (*Sturnus vulgaris* Linn.), which has reached the Kermadecs from New Zealand.

We have referred it to Nitzsch's species as the general form of the head is similar to that of *P. leontodon*.

Philopterus fuscoclypeatus n. sp.

A single mutilated individual, which is almost certainly a female, of this species was collected by one of us from a skin of *Oestrelata neglecta* Schl. sent to Sydney. We have ventured to describe it, in spite of its condition, as the structure of the fore part of the head very clearly distinguishes it from any *Philopterus* so far known.

Fig. 4.

Philopterus fusco-clypeatus. ♀.

Head broader than long; temples evenly rounded, and fore part of form of an equilateral triangle, with anterior angle truncated; from base of trabeculae sides of forehead are perfectly straight to anterior clypeal angles; clypeus entirely brown, darker at sides, where the antennal bands widen out, ending in a more or less sinuous border extending from the anterior clypeal angle, parallel to the long axis, back to the suture; anterior clypeal angles projecting slightly beyond the anterior margin of the clypeus, which is almost straight, there being only a slight median depression; clypeus wholly chitinized, with no clear margins or spaces, with hind margin passing almost straight across the head, curving slightly back on to the centre of the clear space in front of mandibles; laterally the hind margin curves round to join the antennal

bands, and in each lateral curve is a small tubercle; in front of mandibles, and internal to lateral bands, a more or less oblong uncoloured space, containing in its centre a dark oblong blotch with serrated lateral margins: trabeculae fairly strong, coloured, and extending to 2nd segment of antennae; on dorsal surface, at base of trabeculae, an acutely conical process set in a papilla, resembling those found in *Giebelia;* antennae short, slightly bent from 2nd segment, with 1st segment longest, then 2nd, then 5th; 3rd and 4th equal and shorter; eye not prominent, with bristle; occipital bands strong, very slightly converging from the anterior angles of the prothorax to the base of the mandibles; temples dark, mammillated, with at least 2 pustulated hairs about angles; occipital signature conical, the apex meeting a second larger cone, with its base along the articulations of the mandibles; between these and the occipital bands, subtriangular uncoloured spaces; hind margin slightly sinuous, projecting a little on to prothorax; oesophageal sclerite and glands fairly conspicuous (in cleared specimen); few hairs are observable; beyond the pustulated hairs already mentioned only a short hair at trabecular angle and a stout spine behind the eye can be made out, but the hairs may easily have been abraded off the specimen.

Prothorax half as long as head, and seven-tenths as wide; with slightly convex posterior margin; angles rounded, and sides converging anteriorly; lateral areas brown, with median uncoloured space; apparently 1 spine and 1 small pustulated hair in posterior angle. Metathorax about half as long as prothorax, and wider, with sides convexly diverging from in front to prominent postero-lateral angles, thence curving to an almost straight hind margin; a spine and a hair in postero-lateral angle; and apparently a couple of pustulated hairs on either side on hind margin; latter with a strong brown band on its free portion; all, except a median uncoloured line, of uniform brown colour; sternal markings of two pairs of very strong intercoxal lines, the posterior pair forming T-shaped structures with lateral lines external to the coxae.

Abdomen of 9 segments, orbicular, widest at 4th segment, and with last segment small and apparently bifid; the first 7 segments with triangular lateral blotches, elongated inwards; blotches of 8th segment quadrilateral; 9th with only small suffused blotch; 1 to 3 pustulated hairs in posterior angles of segments, and a few hairs along hind margins, as well as several on the uncoloured space in centre of abdomen; but no accurate description of the number and disposition of hairs is possible, owing to the condition of the specimen; on the ventral surface, small blotches corresponding in shape to those of segment 8; no genitalia observable.

Total length, 1·38 mm.; breadth, 0·60 mm.; head, 0·42 mm. by 0·50 mm.

It is unfortunate that we have not at our disposal better material of this species, which we have included in the genus *Philopterus*, but which presents some affinities with *Giebelia*. From this genus, however, it is clearly marked off by the uniform chitinization of the dorsal surface of the clypeus, and the absence of the ventral membranous flap. When more material is available it may be necessary to make the species the type of a new genus.

Philopterus wallacei n. sp.

This species has the general form and characters of *Philopterus fuliginosus* Kellogg (1896, p. 80) from *Charadrius squatarola*, but differs in the following points: Length is 1·67 mm. against 1·62 mm., breadth 0·95 mm.

against 0·65 mm., so that, besides being slightly longer, it is proportionately much broader. Head measurements are 0·76 mm. by 0·72 mm., as against 0·60 mm. by 0·53 mm. Antennal bands are produced inwards further, and end in a rounded posterior prolongation. The narrow bands on the hind margins of the first six terga are more distinct than those indicated in Kellogg's figure of *P. fuliginous*, and, moreover, are only very narrowly interrupted medianly. The lateral blotches on the final segment of the abdomen are not so pronounced, nor is the abdomen so distinctly turbinated. There are also a few minor differences in the number and arrangement of hairs.

Fig. 5.
Philopterus wallacei.
♂

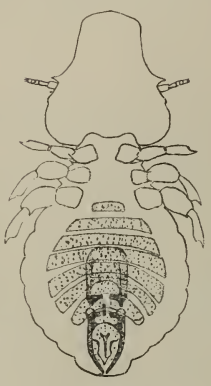

Fig. 6.
Philopterus wallacei.
Ventral.

We have figured the disposition of the chitinous markings on the ventral surface of the abdomen, as well as the genital apparatus, which is extraordinarily large and complex, and continues through six abodminal segments, as in *P. fuliginosus*.

One male from *Charadrius dominicus* Müll. We have named the species in compliment to Mr. W. L. Wallace, to whom its discovery is due.

Philopterus armatus n. sp.

Females of two species of the genus *Philopterus* were taken from *Numenius variegatus* Scop., both of the *fuliginosus* type, and closely allied to one another. They are easily distinguishable, however, the present species being larger, and having the head broader in proportion (as well as different in the disposition of markings), than the next described species. Two males were also collected which we take to belong to this species.

Description of Female.—Head a seventh broader than long, truncate, with obtusely rounded anterior angles, concave sides to the trabeculae, and much swollen temporal lobes; hind margin sinuous, with central rounded projection on to prothorax; clear brown, with the strong mandibles, antennal bands, and acuminate point of signature much darker. Clypeus with narrow lateral bands, clear anterior margin, distinct suture, and an evenly chitinized signature, parallel to the anterior and lateral margins, with semicircular posterior margin, and strongly projecting posterior acuminate joint, rising from just inside hind margin. Antennal bands strong, ending in a rounded enlargement at the antennary fossa; internal to antennal bands, 2 strong bent bands rise from the articulating process for the mandibles, curving strongly to pass round the anterior ends of the antennal bands, thence running straight to the anterior ends of the clypeal bands, just posterior to the clypeal angles; in the curve of these bands, on either side, a strong chitinous blotch; trabeculae light in colour, reaching to the middle of 2nd segment of antenna; antennae light, with short stout 1st joint, 2nd longest, 3rd and 5th equal and shorter, 4th shorter still; eye fairly prominent, clear outwardly, with a pigment

spot on inner margin, with two bristles; before and behind eye a narrow marginal band; occipital bands practically absent, being indicated only by the inner margins of the even-coloured temporal lobes; 6 hairs in front of trabecula, and a very short bristle on its base; 2 pairs of hairs on dorsal surface in front of mandibles; 2 hairs with a short spine between at temporal angles, and 2 spines external to prothorax on either side of hind margin.

Prothorax projecting under occiput, with slightly diverging sides, rounded angles, then converging sides to short, straight hind margin.

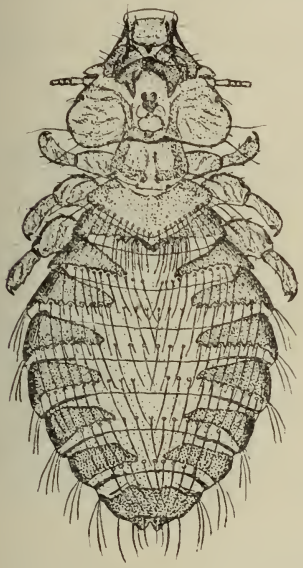

Fig. 7.
Philopterus armatus. ♂.

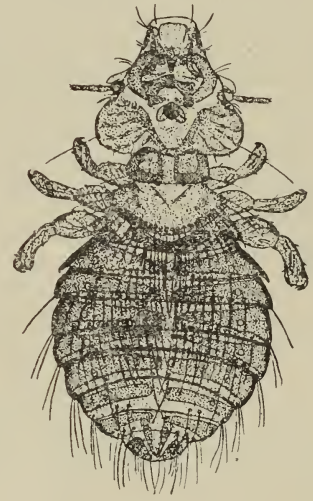

Fig. 9.
Philopterus armatus. ♀.

Fig. 8.
Philopterus armatus.
Ventral. ♂.

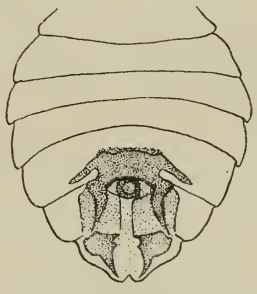

Fig. 10.
Philopterus armatus.
Ventral. ♀.

Where the converging sides meet the straight margin are two little folds in the chitinous border. A single hair in the angle. A fairly strong lateral band extending along more than one-third of hind margin. Metathorax convexly divergent to a truncated postero-lateral angle, with 3 strong hairs; hind margin obtusely rounded, strongly projecting on to abdomen, with a series of about 20 pustulated hairs, in addition to the 6 already mentioned; with short dark antero-lateral bands.

Abdomen of 9 segments, elongate-oval, with strong lateral bands to first seven segments; transverse bands of 1st segment meeting in the middle line; of 8th segment continuous; of segments 2–7 short, extending from two-fifths to one-quarter across width of abdomen, and leaving a large clean central area; segment 9 very short, and slightly bifid, with small dark oval blotch in either lobe; each segment, except the last, with a series of pustulated hairs along the hind margins of the transverse bands, in the anterior segments embraced in serrations of the bands themselves, but becoming removed from the bands as we proceed posteriorly, so that the hind margin of the band of segment 6 is only slightly serrated, while that of segment 7 is entire; posterior end of lateral band of segment 2 forms a strong spinous projection, and there is a similar but less prominent projection in segment 3; 1 to 3 hairs in posterior angles of segments 3 to 8; segment 9 with a prickle on either lobe. Genital blotch prominent, and best understood by reference to the figure.

Length, 2·42 mm.; breadth, 1·05 mm.; head, 0·74 mm. by 0·84 mm.

Description of Male. — Generally smaller and darker than female, with golden-brown head and dark-brown abdomen; head not so wide in proportion as that of female, but with the same markings, except that the two small markings in the curve of the inner antennal band are absent; marginal bands of prothorax stronger; abdomen pyriform, widest at 3rd and 4th segments, thence abruptly tapering to a longer 9th segment, with obtusely rounded angles, and an almost flat hind margin; segments 2 to 7 with very strong lateral bands of blackish brown; posterior angles of segment 1 rounded under segment 2; of segments 2–5 strongly projecting, segment 3 especially so, with a strong spine; chitinous parts of segment 9 standing out dorsally as a flattened semicircular prominence, the lateral borders of which are inside the actual margin of the segment; with 2 strong lateral blotches, connected by a narrow line along the hind margin, and much broken by large pustules, bearing hairs, about 20 in all; transverse bands of segment 1 meeting mesially, and of the remaining segments separated by a narrow median line; hind margin of segments 2 to 6 bordered by a narrow dark line, hardly interrupted mesially; genitalia complex, generally resembling those of *P. wallacei*, but differing in being partly obscured on the ventral side by a striated chitinous supporting plate and in the narrower chitinous bands.

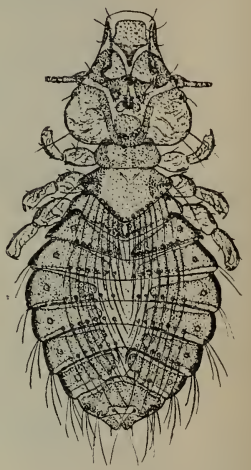

Fig. 11.

Philopterus numeniicola. ♀.

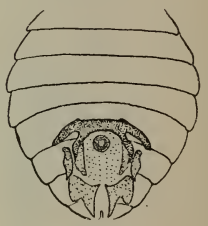

Fig. 12.

Philopterus numeniicola. Ventral.

Length, 1·98 mm.; breadth, 0·91 mm. Head: Length, 0·67 mm.; breadth, 0·69 mm.

Philopterus numeniicola n. sp.

Two females from *Numenius variegatus* Scop. This species bears a strong general resemblance to the last, but is smaller, the head is longer

and narrower, the prothorax different in shape, and there are other minor differences.

Description of Female.—Head longer than broad, with elongate concave-sided clypeus, evenly rounded temporal lobes, and slightly concave hind margin, with very small median rounded projection on to prothorax; markings much the same as in the last species, save that the suture is much more distinct. the acuminate point of the signature is forked anteriorly, the inner antennal bands do not reach so far forward, and the occipital bands are well defined; prothorax with sides converging anteriorly, and hind margin slightly convex; metathorax with postero-lateral angles not truncated, but acute, and with deeper and more angulated projection on to abdomen; hind margin with about 20 pustulated hairs, not 26. Abdomen more roundly oval, with last segments not so much produced; transverse bands not so distinctly angulated at apex, and produced further inwards, leaving a much smaller clear space; the pustulated hairs of the segments generally fewer in number, ranging from 6 on segment 1, through from 12 to 14 on the intervening segments, to 4 on segment 7; 1 to 3 hairs in the posterior angles, except the first, which is without hairs; genital blotch closely resembling that of the last species, and more easily compared on reference to the figures.

Length, 1·97 mm.; breadth, 0·91 mm.; head, 0·66 mm. by 0·60 mm.

TRICHODECTIDAE.

Trichodectes climax Nitzsch, in Giebel (1874, p. 58, pl. 20, fig. 2).

Many specimens of both sexes were obtained from the introduced domestic goat (*Capra hircus* Linn.).

The types of the new species and variety described in this paper are deposited in the Dominion Museum, Wellington, New Zealand. Where there has been sufficient material, cotypes have been retained in our own collection.

All the figures in this article have been drawn with a camera lucida, and have been equally magnified.

LITERATURE LIST.

1842. Denny. "Monographia Anoplurorum Britanniae." London.
1910. Iredale. "Bird Life on the Kermadec Islands." "The Emu," vol. 10, pp. 2–16.
1896. Kellogg. "New Mallophaga," vol. 1. (Contributions to Biology from the Hopkins Seaside Laboratory, iv.) Palo Alto, Cal.
1899. Kellogg and Chapman. "New Mallophaga," vol. 3. (Contributions to Biology from the Hopkins Seaside Laboratory," xix). San Francisco.
1092. Kellogg and Kuwana. "Mallophaga from Birds of Galapagos." Proc. Wash. Acad. Sci., vol. 4, p. 457.
1908. Kellogg. Mallophaga in Wytsman's "Genera Insectorum." Brussels.
1874. Nitzsch. In Giebel, "Insecta Epizoa." Leipzig.
1880. Piaget. "Les Pédiculines, Essai Monographique." Leyden.
1885. ——— ——— Supplement. Leyden.
1874. Westwood. "Thesaurus entomologicus oxoniensis."

Art. XXXIX.—*Vascular System of* Siphonaria obliquata *Sowerby.*

By A. J. Cottrell, M.A., M.Sc. (N.Z.).

Communicated by Professor Benham.

[*Read before the Otago Institute, 3rd October, 1911.*]

In a previous paper (Trans. N.Z. Inst., vol. 43, 1911, p. 582) I described the general anatomy of *Siphonaria obliquata*, the common limpet-like marine Gastropod, whose affinities are still undecided; for, while some authorities incline to the view that it is a modified Opisthobranch, others, and perhaps the majority, regard it as a Pulmonate. I now supplement that article by giving here an account of the vascular system, which was omitted purposely from that paper.

The adaptation of *Siphonaria* to a life along the sea-shore, where at times it is below water, at other times above, is well illustrated by its "dipnoan" character, having, that is, both a lung and a gill, each with its own independent blood-supply. If, as seems the more probable, it is a Pulmonate which has left its terrestrial home and ventured back into the original habitat of the Gastropod molluscs, we must look on the gill as a new structure, analogous to those of such forms as the Prosobranch, *Patella* (limpets), and the Opisthobranch, *Pleurophyllidia*, which has arisen in relation to this new mode of life—that is, it is an "adaptive" gill, as in these forms. Its structure is not that of a typical ctenidium, as I pointed out in my previous article, though it has some resemblance to certain gills amongst the Opisthobranchs. We already know a few Pulmonates which have taken to an aquatic life in which a gill is present. Thus, in *Isidora*, *Protancylus*, and others there is a single-folded lamina; but in *Siphonaria*, as I have described it in my previous article (p. 585), there is a series of independent laminae arranged in a semicircle round the mantle-cavity, each lamina bearing secondary laminae, so that it is much more complex than the gill in the above Pulmonates.

Lang regards these pulmonate gills as probably ctenidia, though Pelseneer and others hold them to be "adaptive" gills. On the other hand, supposing that *Siphonaria* is an Opisthobranch which has become able to remain out of water for a considerable portion of each day, and to breathe air during this period, we must suppose that it is the lung that is the new thing; and although, so far as I am aware, no Opisthobranch has been found to have a lung, yet amongst the Prosobranchs several genera, belonging to different families, have developed a network of blood-vessels on the mantle-roof; so that the cavity acts as a lung, and the genera can be arranged in series, in which the ctenidium gradually decreases in size and importance till it remains as a mere vestige (as in *Cerithidea*).

Hence, whatever view is taken as to the affinities of *Siphonaria*, it remains an extremely interesting form to biologists, having either an adaptive lung or an adaptive gill.

The Heart.

The heart lies in the pericardium on the left side of the dorsal surface of the body, just in front of the middle of the length. The position of the heart, as seen in the animal after the shell has been removed, is shown in fig. 7 of plate 28 of my former article. The walls of the pericardium

are formed by a thin tough transparent membrane. The heart, as usual, is two-chambered, the ventricle being situated to the left of the auricle, its apex pointing to the left and downwards, while the auricle lies almost horizontally and transversely to the body. The walls of the auricle are thin, transparent, and extremely delicate. When this chamber is distended with blood the bluish tinge of the latter may be noticed,

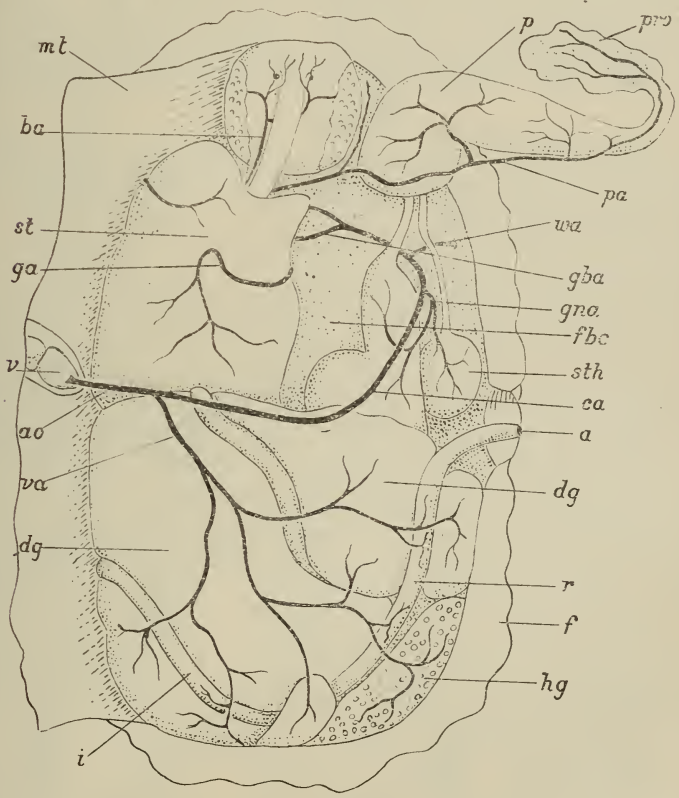

Fig. 1.

Dissection of the animal, showing the chief arteries; × 2. Dorsal wall of body (mantle) with heart and pericardium turned to the left, exposing the ventral surface of the heart. *a.*, anus; *ao.*, aorta; *b.a.*, superior buccal artery; *c.a.*, cephalic aorta; *d.g.*, digestive gland; *f.*, edge of foot; *f.b.c.*, floor of body-cavity and upper surface of foot; *gn.a.*, genital artery; *g.a.*, gastric artery; *g.b.a.*, gastro-buccal artery; *h.g.*, hermaphrodite gland; *i.*, intestine; *p.a.*, penial artery; *p.*, penis; *pro.*, prostate; *v.a.*, visceral aorta; *v.*, ventricle; *sth.*, spermotheca; *st.*, stomach *r.*, rectum; *w.a.*, artery to body-wall; *m.t.*, mantle turned aside.

due to the presence of the respiratory pigment, haemocyanin, characteristic of the respiratory fluid of *Mollusca* and *Arthropoda*. In this distended condition the auricle is of a more or less cylindrical shape, the long axis being transverse to the body. Two large veins discharge blood into this chamber, uniting just as they reach it. From the auricle the blood or haemolymph passes between the two auriculo-ventricular valves into the ventricle. Owing to the fact that it possesses thicker walls the

ventricle is of more definite and constant shape than the auricle; from above it is broad at the auricular end and tapers to the other extremity, where it ends in a blunt point. After removal of the auricle the valves can be seen partly open, leaving the silt-like orifice through which the blood passes to the ventricle. When the ventricle contracts, the lips of these valves come together and close the passage. This action can be well seen by filling the chamber with water and gently squeezing it. The walls of the ventricle are stout and muscular, and from the exterior can be seen the multitude of muscular fibres running in varying directions in them. Most of the fibres converge on a stout ring formed round the exit of the aorta; their other ends, often branched, are attached to the walls.

Arteries.

The aorta leaves the ventricle near the middle of its ventral side, and, piercing the pericardial wall, to which it is firmly attached, takes a course almost directly transversely towards the right and a little backwards, passing between the anterior lobes of the digestive gland till it reaches the intestine. At this point it bifurcates, giving rise to the cephalic aorta (fig. 1, *c.a.*), supplying the anterior region of the body, and the visceral aorta (*v.a.*), supplying the posterior organs. This passes backwards among the lobes of the digestive gland, and divides into three main branches, which carry blood to that organ, to the hermaphrodite gland, intestine, and posterior end of the stomach. For the purpose of studying the distribution of the arteries I injected coloured "starch injection" into the ventricle, and was successful in obtaining a beautiful preparation showing even the smaller branches, but could not afford time, nor did I consider it worth while, to work out the distribution of the visceral aorta in further detail.

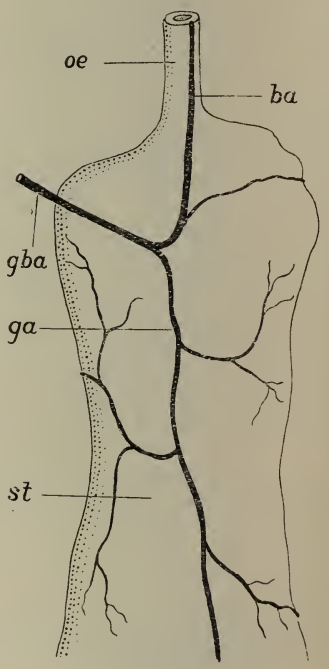

Fig. 2.

Arteries on the ventral side of stomach; × 4. *b.a.*, superior buccal artery; *g.b.a.*, gastro-buccal artery; *g.a.*, gastric artery; *oe.*, oesophagus; *st.*, stomach.

The cephalic aorta passes to the right over the dorsal surface of the viscera, and comes in contact with the body-wall (*i.e.*, the floor of the pallial chamber) just below the kidney. Continuing its course to the right, it curves forwards till it reaches the spermothecal duct, in front of which it passes downwards and forwards on to the floor of the body-cavity. Just before reaching this point it gives off the genital artery (*gn.a.*), which, passing backwards, supported by a thin membrane, gives rise to the vessels of the spermotheca and genital duct. The cephalic aorta now runs forwards for a short distance on the floor of the body-cavity, and after giving off a vessel (*w.a.*) which disappears into the muscles of the right body-wall and foot it turns to the left and reaches the nerve-collar, through which it passes below the oesophagus.

A little before reaching this point the cephalic aorta gives rise to a large branch—the gastro-buccal artery (*g.b.a.*), which passes to the left along the floor of the body-cavity, reaching the stomach on the ventral surface a little behind the point where the oesophagus (fig. 2) enters. Here it an once bifurcates, one branch—the superior buccal artery (*b.a.*)—going forwards to the buccal mass, and the other—the gastric artery (*g.a.*)—backwards along the ventral wall of the stomach.

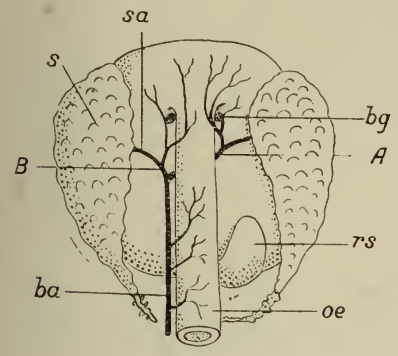

FIG. 3.

Arteries supplying the dorsal surface of buccal mass; × about 4. A, right branch of buccal artery, which passes below the oesophagus; B, left branch of buccal artery; *b.g.*, buccal ganglion; *b.a.*, superior buccal artery; *r.s.*, end of radular sac; *s.a.*, right salivary artery; *s.*, salivary gland; *oe.*, oesophagus.

The superior buccal artery passes forwards as a large vessel along the left latero-ventral side of the oesophagus, and turns up with the latter on to the dorsal surface of the buccal mass, giving off small vessels to the oesophagus on the way. On reaching a point a little behind the buccal ganglia it bifurcates into right and left branches, A and B respectively (fig. 3). Branch A passes under the oesophagus to the right side, and gives off the artery which supplies the salivary gland. It then passes on to the latero-dorsal surface of the oesophagus and sends out a branch to the right buccal ganglion. These ganglia are well supplied with blood-vessels, and when the latter are well injected appear to be encased in an envelope of small arteries. An artery also runs on to the commissure connecting these ganglia. Beyond this point branch A passes to the anterior end of oesophagus, and finally dips into the anterior muscles of the buccal mass. Branch B of the superior buccal artery has a similar distribution on the left side.

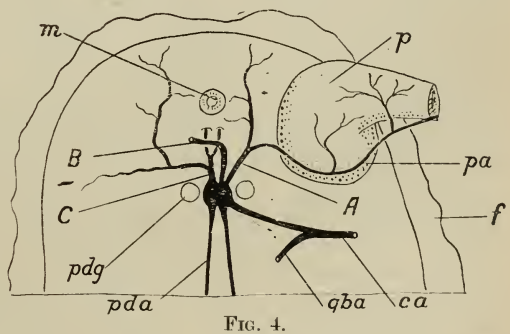

FIG. 4.

Arteries on the floor of the body supplying the head and foot, as seen when the buccal mass is severed; × 2. A, B, and C, the three main arteries supplying the head; B is the inferior buccal artery, and is cut short; *c.a.*, cephalic aorta (which is much swollen at the point where it branches as it passes between the pedal ganglia); *g.b.a.*, gastro-buccal artery; *m.*, mouth (buccal mass being removed); *p.a.*, penial artery; *pd.a.*, pedal artery; *pd.g.*, pedal ganglion.

Thus this branch of the gastro-buccal artery, which I have called the superior buccal, to distinguish it from another vessel (the inferior buccal artery), supplies the oesophagus, salivary glands, buccal ganglia, and some of the dorsal muscles of the buccal mass.

The gastric artery (fig. 2) takes a backward course on the ventral side of the stomach, giving off branches to the ventral surface of the stomach; the extreme posterior of this organ, however, is supplied by a branch of the visceral aorta.

Returning to the cephalic aorta, which we traced above as far as the nerve-collar, we find that as it passes between the pedal ganglia it breaks up into a number of large vessels, some of which run forwards on the floor of the body-cavity, supplying the organs and walls of this region, and some pass backwards, supplying the foot (fig. 4).

Running forwards we have three main arteries—A, B, C (fig. 4). The first of these, A, supplies the ventral wall of the head, penis, and muscles round the mouth. It would appear from Captain Hutton's figure that the penial artery was mistaken by him for the vas deferens.*

B, which I term the inferior buccal artery, arises to the left of A, goes directly into the buccal mass on its ventral side, and supplies almost the whole of this organ. To the left of B again is the branch C, which is the largest of the three: very near its origin it bifurcates into right and left branches, the latter corresponding to A of the right side. The right branch runs forwards for a short distance, where it bifurcates, the rami entering the muscular ventral wall of the head. Running backwards from the cephalic aorta at this point are two large arteries, right and left, which disappear among the muscles of the foot (*pd.a.*).

Veins.

The distribution of the veins is illustrated in my previous article (Trans. N.Z. Inst., vol. 43, pl. 28, fig. 7, and pl. 29, fig. 2).

In the foot and body-walls are numerous large blood-vessels or spaces, and into these, as far as I have been able to make out, most of the blood eventually makes its way. Part of this blood is collected by a large vein which runs vertically up in the left body-wall near the end of the gill; on reaching the dorsal surface it bifurcates, one branch —posterior renal vein—being distributed to the kidney, and the other—the afferent branchial vein—running round the posterior border of the gill, and distributing blood to the gill-lamellae.

Near the respiratory orifice it gives off a large branch—the anterior renal vein—which runs between the gill-lamellae on to the kidney close to the renal papilla, a process of which surrounds the vessel between its origin and the kidney. This vessel has been figured lightly, as it lies deeper than the other vessels, and its reference-line has been misplaced in the figure (vol. 43, pl. 28, fig. 7). Connected with the afferent branchial vein along its whole length there are a large number of pallial vessels. The blood passes from this vein through the gill, where it is aerated, into the efferent branchial vein, which runs round the anterior margin of the gill. This vein returns blood to the auricle partly by a vein, leaving it half-way along the gill and crossing the kidney, from which it receives several small vessels, and partly by the efferent pulmonary vein, which it joins at the right end of the gill. This latter vessel receives blood from the efferent vessels of the lung and enters the auricle together with the efferent vessel crossing the kidney.

Another large vein receiving blood from the body generally is the afferent pulmonary vein, which emerges from the body-wall just in front of the pericardium, and runs round the anterior margin of the lung, giving rise to the afferent vessels of the lung. The blood passes through these, and reaches the efferent vessels, which carry it to the efferent pulmonary

* Trans. N.Z. Inst., vol. 15, pl. 17, fig. B, *c*.

vessel, and so to the auricle. There is thus always arterial or aerated blood in the heart, and purification of the blood is effected in the mantle, which is everywhere very vascular, as well as in the two respiratory organs connected with it.

For the purpose of tracing out the blood-vessels I injected from the heart backwards and forwards. From the auricle I injected backwards "berlin blue" very successfully into the vessels of the gills, lungs, and kidney; and forwards through the ventricle I tried Parker's "starch injection" and "glycerine carmine": the former gave me the most satisfactory results.

Art. XL.—*Descriptions of New Genera and Species of* Coleoptera.

By Major T. Broun, F.E.S.

[*Read before the Auckland Institute, 22nd November, 1910.*]

In the following list the names and numbers (3157–3163) of new species of *Byrrhidae* recorded in Bulletin No. 2 of the New Zealand Institute are prefixed so as to succeed the last number in Bulletin No. 1. This was necessary to make the numbering consecutive, and to prevent these species being overlooked.

Within the present year (1910) descriptions of seven new genera and 189 species of New Zealand beetles have been prepared. To these are added, in their proper places, eight species of *Pselaphidae* published in the German language by Herr Reitter, of Vienna.

This unexpectedly large addition, to a great extent, is the result of explorations of different peaks of the Tararua Range by Messrs. A. O'Connor and H. W. Simmonds, of Wellington, and of portions of the Southern Alps by Mr. H. Hamilton, also a resident of that city. Mr. W. L. Wallace, of Timaru, during the unfavourable part of the collecting season managed to secure several new species on the Kaikoura Range. Various localities near the elevated Waimarino Plateau, owing chiefly to the assistance rendered by Mr. W. J. Guinness, yielded about a third of the total number collected during the year. In all cases credit is given, in the descriptive part of this paper, to every individual who helped to produce the general result.

The foregoing remarks incontestably prove that our knowledge of the insect fauna of the higher altitudes is very imperfect, notwithstanding the fact that 3,360 species of *Coleoptera* have been found in New Zealand. It may also be stated that a considerable proportion of these alpine beetles are exponents of distinct genera, and, as a rule, are finer or more interesting than those of corresponding groups procured on the lowlands.

Of Stewart Island we know scarcely anything entomologically, only one species, so far as I can remember, having been described from that region, which, if carefully searched, will probably yield some forms more or less allied to those obtained by the members of the recent expedition to the subantarctic islands.

List of New Genera and Species.

Group Byrrhidae.

3157. Synorthus mandibularis *Broun.*
3158. ,, laevigatus *Broun.*
3159. ,, pygmaeus *Broun.*
3160. Pedilophorus foveigerus *Broun.*
3161. ,, sculpturatus *Broun.*
3162. ,, cognatus *Broun.*
3163. ,, bryobius *Broun.*

Group Cnemacanthidae.

3164. Mecodema o'connori *Broun.*
3165. ,, bryobium *Broun.*
3166. ,, laevicolle *Broun.*
3167. ,, quoinense *Broun.*
3168. ,, arcuatum *Broun.*

Group Anchomenidae.

3169. Ctenognathus simmondsi *Broun.*
3170. Tarastethus amplipennis *Broun.*
3171. ,, phyllocharis *Broun.*
3172. ,, lewisi *Broun.*
3173. ,, cordipennis *Broun.*

Group Pogonidae.

3174. Oöpterus laevigatus *Broun.*

Group Feronidae.

3175. Trichosternus wallacei *Broun.*
3176. Pterostichus hamiltoni *Broun.*

Group Anisodactylidae.

3177. Allocinopus smithi *Broun.*
3178. ,, castaneus *Broun.*
3179. ,, angustulus *Broun.*
3180. Zabronothus major *Broun.*
3181. ,, aphelus *Broun.*

Group Aleocharidae.

3182. Aphytopus porosus *Broun.*
3183. ,, granifer *Broun.*
3184. ,, guinnessi *Broun.*
3185. Calodera wallacei *Broun.*
3186. ,, fultoni *Broun.*
3187. Myrmecopora funesta *Broun.*
3188. ,, granulata *Broun.*

Group Staphylinidae.

3189. Quedius eruensis *Broun.*
3190. ,, xenophaenus *Broun.*

Group Pederidae.

3191. Lithocharis longipennis *Broun.*
3192. Dimerus whitehorni *Broun.*

Group Osoriidae.

3193. Holotrochus setigerus *Broun.*

Group Oxytelidae.

3194. Bledius bidentifrons *Broun.*

Group Pselaphidae.

3195. Sagola monticola *Broun.*
3196. Euglyptus foveicollis *Broun.*
3197. ,, longicornis *Broun.*
3198. Euplectopsis longicollis *Reitter.*
3199. ,, macrocephalus *Reitter*
3200. ,, brevicollis *Reitter.*
3201. ,, rotundicollis *Reitter.*
3202. ,, trichonyformis *Reitter.*
3203. ,, schizocnemis *Broun.*
3204. ,, carinatus *Broun.*
3205. ,, antennalis *Broun.*
3206. ,, eruensis *Broun.*
3207. ,, heterarthrus *Broun.*
3208. ,, biimpressus *Broun.*
3209. Pycnoplectus cephalotes *Reitter.*
3210. Vidamus calcaratus *Broun.*
3211. ,, incertus *Reitter.*
3212. Plectomorphus optandus *Broun.*
3213. ,, longipes *Broun.*
3214. Byraxis monstrosa *Reitter.*
3215. ,, rhyssarthra *Broun.*

Group Silphidae.

3216. Choleva caeca *Broun.*
3217. ,, castanea *Broun.*
3218. Camiarus estriatus *Broun.*
3219. Silphotelus obliquus *Broun.*

Group Colydiidae.

3220. Syncalus explanatus *Broun.*
3221. Tarphiomimus tuberculatus *Broun.*
3222. Ulonotus uropterus *Broun.*
3223. ,, wallacei *Broun.*
3224. Notoulus demissus *Broun.*
3225. Bitoma maura *Broun.*

Group Pycnomeridae.

3226. Pycnomerus reversus *Broun.*
3227. ,, candidus *Broun.*

Group Bothrideridae.

3228. Bothrideres diversus *Broun.*

Group Cryptophagidae.

3229. Cryptophagus amoenus *Broun.*

Group Lathridiidae.

3230. Corticaria fuscicollis *Broun.*

Group Byrrhidae.

3231. Pedilophorus opaculus *Broun.*

Group Copridae.

3232. Saphobius lepidus *Broun.*

Group Melolonthidae.

3233. Odontria nitidula *Broun.*
3234. ,, monticola *Broun.*
3235. ,, similis *Broun.*
3236. Costleya simmondsi *Broun.*

Group Eucnemidae.

3237. Talerax dorsalis *Broun.*

Group Elaleridae.

3238. Protelater diversus *Broun*
3239. Chrosis dubitans *Broun.*
3240. Corymbites fulvescens *Broun.*
3241. ,, vitticollis *Broun.*
3242. ,, approximans *Broun.*
3243. ,, sternalis *Broun.*

Group Dascyllidae.

3244. Atopida basalis *Broun.*
3245. Mesocyphon mandibularis *Broun.*
3246. Cyphon pachymerus *Broun.*

Group Melyridae.

3247. Arthracanthus foveicollis *Broun.*

Group Cleridae.

3248. Phymatophaea griseipennis *Broun.*
3249. Parmius violaceus *Broun.*

Group Anobiidae.

3250. Anobium inaequale *Broun.*
3251. ,, niticolle *Broun.*

Group Opatridae.

3252. Syrphetodes truncatus *Broun.*

Group Diaperidae.

3253. Menimus lineatus *Broun.*

Group Helopidae.

3254. Adelium complicatum *Broun.*
3255. Cerodolus curvellus *Broun.*

Group Anthicidae.

3256. Cotes insignis *Broun.*

Group Melandryidae.

3257. Hylobia plagiata *Broun.*
3258. ,, guinnessi *Broun.*

Group Otiorhynchidae.

3259. Nicaeana nesophila *Broun.*
3260. Epitimetes grisealis *Broun.*
3261. Nonnotus nigricans *Broun.*
3262. Tigones rugosa *Broun.*
3263. ,, albopicta *Broun.*
3264. Platyomida hamiltoni *Broun.*
3265. ,, morosa *Broun.*
3266. Lyperobates guinnessi *Broun.*
3267. ,, elegantulus *Broun.*
3268. ,, rostralis *Broun.*
3269. ,, punctatus *Broun.*
3270. Phaeocharis cuprealis *Broun.*
3271. ,, punctatus *Broun.*
3272. Notiopatae terricola *Broun.*
3273. Getopsephus acuminatus *Broun.*
3274. Brachyolus labcculatus *Broun.*
3275. ,, varius *Broun.*
3276. Agatholobus waterhousei *Broun.*

Group Rhyparosomidae.

3277. Phrynixus setipes *Broun.*
3278. ,, binodosus *Broun.*
3279. Lithocia acuminata *Broun.*
3280. Bradypatae minor *Broun.*
3281. Clypeorhynchus calvulus *Broun.*
3282. ,, caudatus *Broun.*
3283. Phemus curvipes *Broun.*
3284. ,, constrictus *Broun.*
3285. Sosgenes planirostris *Broun.*
3286. Rachidiscus multinodosus *Broun.*
3287. Phygothalpus sulcicollis *Broun.*

Group Cylindrorhinidae.

3288. Tocris aterrima *Broun.*
3289. ,, hamiltoni *Broun.*
3290. Heteromias foveirostris *Broun.*
3291. Geochus posticalis *Broun.*

Group Erirhinidae.

3292. Erirhinus titahensis *Broun.*
3293. ,, oleariae *Broun.*
3294. ,, exilis *Broun.*
3295. Dorytomus maorinus *Broun.*
3296. ,, consonus *Broun.*
3297. Aneuma spinifera *Broun.*
3298. Eugnomus calvulus *Broun.*
3299. ,, dennanensis *Broun.*
3300. Oreocharis albosparsa *Broun.*
3301. ,, veronicae *Broun.*
3302. ,, picipennis *Broun.*
3303. ,, uniformis *Broun.*
3304. ,, dives *Broun.*
3305. ,, castanea *Broun.*
3306. Hoplocneme vicina *Broun.*
3307. Pactola nitidula *Broun.*
3308. ,, fuscicornis *Broun.*
3309. ,, binodiceps *Broun.*

Group Anthonomidae.

3310. Hypotagea lewisi *Broun.*

Group Cryptorhynchidae.

3311. Psepholax acanthomerus *Broun.*
3312. Mesoreda longula *Broun.*
3313. Acalles conicollis *Broun.*
3314. ,, cruensis *Broun.*
3315. ,, peelensis *Broun.*
3316. ,, consors *Broun.*
3317. ,, gracilis *Broun.*
3318. ,, contractus *Broun.*
3319. Tychanus costatus *Broun.*
3320. Crisius humeralis *Broun.*
3321. ,, semifuscus *Broun.*
3322. ,, decorus *Broun.*
3323. Tychanopais flavisparsus *Broun.*
3324. Allanalcis ignealis *Broun.*
3325. ,, oculatus *Broun.*
3326. ,, dilatatus *Broun.*
3327. Metacalles crinitus *Broun.*
3328. ,, lanosus *Broun.*
3329. Zeacalles pictus *Broun.*
3330. ,, femoralis *Broun.*
3331. Onias irregularis *Broun.*
Xenacalles gen. nov. Type 1427.
3332. Getacalles substriatus *Broun.*

Group Cossonidae.

3333. Pentarthrum impressum *Broun.*
3334. ,, tenebrosum *Broun.*

Group Anthribidae.

3335. Eugonissus turneri *Broun.*
3336. ,, sylvanus *Broun.*
3337. Anthribus cornutellus *Broun.*
3338. ,, levinensis *Broun.*
3339. ,, obscurus *Broun.*
3340. ,, wairirensis *Broun.*

Group Cerambycidae.

3341. Didymocantha media *Broun.*
3342. ,, oedemera *Broun.*
3343. ,, fuscicollis *Broun.*

Group Lamiidae.

3344. Somatidia thoracica *Broun.*
3345. ,, nodularia *Broun.*
3346. ,, piscoidea *Broun.*

Group Lamiidae—*continued.*

3347. Somatidia posticalis *Broun.*
3348. ,, corticola *Broun.*
3349. ,, pinguis *Broun.*
3350. Tetrorea maculata *Broun.*
3351. Hybolasius cupiendus *Broun.*
3352. ,, tumidellus *Broun.*
3353. ,, rugicollis *Broun.*

Group Eumolpidae.

3354. Pilacolaspis angulatus *Broun.*
3355. ,, latipennis *Broun.*

Group Galerucidae.

3356. Luperus simmondsi *Broun.*
3357. ,, foveigerus *Broun.*
3358. ,, o'connori *Broun.*
3359. ,, atripennis *Broun.*

Group Erotylidae.

3360. Cryptodacne ocularia *Broun.*

Group Cnemacanthidae.

3164. **Mecodema o'connori** sp. nov. *Mecodema* Blanchard, Man. N.Z. Coleopt., p. 7.

Robust, moderately convex, shining, elytra less so; black, legs and antennae rufo-piceous, palpi more rufescent.

Head large, including the mandibles, a fourth longer than the thorax, with a series of fine punctures across it behind the prominent eyes, near which, and on the forehead, the rugae are well marked and longitudinal. Thorax with crenulate margins, which are a little expanded in front; it is slightly broader near the apex than at the middle, and considerably curvedly narrowed behind, so that the base is but little more than half the breadth of the frontal portion, just at the obtusely rectangular angles the sides are almost straight, the apex is slightly but widely incurved, the base truncate, its length is a fourth less than the width; the mesial groove is well marked and ends at the transversal impression near the apex, the basal fossae are deep, placed close to the sides, extend a little inwards, and are limited behind by the raised basal margin; the disc is finely transversely striate, the base and apex longitudinally but indefinitely, near each side there is a shallow foveiform impression. Elytra, oblong-oval, gently narrowed towards the base, which, notwithstanding, is rather broader than that of the thorax; their striae are well marked, the 5 nearest the suture, on each, are closely and distinctly punctured, with plane, broad interstices; near the sides the striae are deeper and broader, and their punctures rather coarser and somewhat transversal, with narrower and more convex interstices; the smooth space outside the 8th stria is rather narrow, and is not prolonged forwards much beyond the posterior femur.

Antennae pubescent from the 5th joint onwards. Legs relatively rather slender, the anterior and intermediate tibiae with moderately prominent external angles.

Underside black, a little nitid, nearly smooth, the terminal ventral segment finely transversely striate, unipunctate at each side of the middle, at the extremity.

The diagnosis shows clearly enough that this cannot very well be confounded with previously described species.

♀. Length, 35 mm.; breadth, 11 mm.

Levin, near Wellington. A single female. This bears the name of its discoverer, Mr. A. O'Connor, who has recently brought to light many interesting beetles from the Tararua Range and other localities.

3165. Mecodema bryobium sp. nov.

Elongate, slightly convex, head and thorax a little shining, elytra rather dull; nigrescent, legs and antennae rufo-piceous.

Head nearly as broad as front of thorax and, including the mandibles, rather longer than it is; rather coarsely rugose, longitudinally at the sides and on the forehead, transversely on the vertex, in line with the back part of the prominent eyes it is rather coarsely rugosely punctate, the sculpture behind consists of short irregular wrinkles and fine punctures. Thorax slightly broader than long, widely yet not deeply incurved in front, lateral margins not definitely crenulate, slightly rounded from the anterior angles to beyond the middle, behind strongly curvedly narrowed, but straight near the obtuse angles, its base little more than half the width of the middle; disc nearly flat; the distinct central furrow does not quite reach the base or apex, both of which are impressed with short longitudinal striae; the well-marked rugae do not extend right across the surface, being somewhat interrupted or irregular; there is no distinct punctation; the basal fossae are deep, and situated close to the lateral and basal margins. Elytra oblong-oval, gradually narrowed towards the base, which, however, is broader than that of the thorax; on each elytron the 5 discoidal striae are narrow and rather finely punctured, but are much more deeply impressed at the base; the intervals between these are nearly quite flat, and under the microscope appear densely and minutely coriaceous; the outer striae are deep, but not coarsely punctured, with subcarinate interstices, which, as well as some of the adjoining ones, are traversed more or less by short transverse impressions.

Underside shining black; the middle of the head with short transverse rugae, its sides with short, dense, very irregular rugosities; prosternum irregularly punctate, flanks of mesosternum densely and rugosely; abdomen finely sculptured, its last segment bipunctate at each side of the middle at the apex.

This bears a considerable resemblance to *M. acuductum* (2602), but the thorax differs in form, being more abruptly contracted at the base; there is no punctation near the anterior angles; the discoidal rugae are more numerous, coarser, and interrupted, and no single one stretches right across the disc; and, moreover, the lateral margins are not perceptibly crenulate. The punctation of the outer elytral striae is entirely different. In 2602 the punctures are deep and subquadrate, and the transverse intervals between them are on about the same level as the longitudinal interstices, just the reverse of what occurs in this species. These are not sexual disparities, as my specimen of each species is of the male sex.

♂. Length, 26 mm.; breadth, 8 mm.

Silverstream, near Wellington. Mr. A. O'Connor informs me that he secured several specimens, on different occasions, amongst moss at the roots of birch-trees only.

3166. Mecodema laevicolle sp. nov.

Elongate, brilliant, nigrescent; legs, antennae, and palpi rufo-piceous.

Head, mandibles included, slightly longer than thorax and, including the convex eyes, almost as broad as it is; nearly smooth, there being only a few fine scattered punctures on the vertex, more numerous ones across the back part just behind the eyes, and a few irregular lateral rugae. Thorax but little broader than long, scarcely broader at the middle than near the front, its sides slightly curvate to beyond the middle and moderately narrowed behind; the base medially truncate, but feebly rounded near the sides, so that the angles appear obtuse, the apex slightly but widely emarginate; lateral margins, and channels, of equal width almost to the base, not perceptibly crenulate; its surface smooth or only obsoletely lineated, the dorsal groove distinct but not attaining the base or apex, basal fossae deep, well limited, and touching the sides and hind margin. Elytra oblong-oval, rather broader than thorax at the base; on each elytron there are 4 discoidal series of rather slender fine punctures, the 6th and 7th series are moderately large and rather coarser than the 5th or 8th; the marginal sculpture, too, is rather fine, and more or less duplicated, the apical irregular and coarser.

Legs stout; external angles of the front pairs of tibiae slightly prominent, posterior pair simple. Antennae with the 5th and following articulations pubescent.

Underside shining back; flank of prosternum moderately punctate and rugose; abdomen smooth, its last segment bipunctate at each side of the middle, at the extremity.

The glossy, rather smooth surface, simple thoracic margins, and deep well-defined basal fossae, distinguish this from all the other species of moderate size. *M. seriatum* (2605) is perhaps the most nearly allied; its sculpture, however, is very different.

♂. Length, 20 mm.; breadth, 6½ mm.

Bold Peak, Wakatipu; altitude, about 6,000 ft. A specimen was given to me by Mr. O'Connor, but its discoverer is Mr. H. Hamilton.

3167. Mecodema quoinense sp. nov.

Elongate, slightly convex, moderately nitid; black, femora and basal joint of antennae piceo-rufous.

Head, mandibles included, a sixth longer than thorax, but rather narrower, with numerous fine punctures behind the small prominent eyes; near these latter there are 3 or 4 curved striae, and some fine transverse ones in front. Labrum slightly rounded, quadripuncate only. Mandibles elongate, obliquely wrinkled, the left particularly. Thorax nearly a third broader than long, widest before the middle, slightly rounded there, gradually curvedly narrowed backwards, without any definite sinuation or contraction near the base, which is medially incurved, with obtuse angles; lateral margins not crenulate, rather narrow, only slightly expanded in front, the apex subtruncate; its sculpture consists of feeble transverse striae, short longitudinal ones in front and at the base, and a few slight punctiform marks near the front and the basal fossae, which are deep, but not large, and situated near the angles; the mesial groove is well marked. Elytra almost twice as long as broad, a little wider than the thorax, their sides gently and evenly curved, so that the apex is nearly as broad as the base; they are punctate-striate, rather finely on the disc; the striae nearest the sides are

deeper and more strongly and closely, yet not very coarsely, punctured; these become convergent, and do not reach the base; the 3rd and 5th interstices are a little broader than the others, the 5th at some distance from the base is split up by a finely punctured stria, the 7th is quadripunctate; the smooth space along each side is rather broad and convex; the marginal punctures are small; the sculpture near the apex becomes coarsely punctiform and irregular, but the margin, though fine, is quite distinct there.

Legs rather thick; the external angle at the apex of the front tibiae is hardly at all prominent, that of the intermediate pair is moderately angulate. Antennae with the basal 4 joints smooth and glabrous, the others finely and closely punctate, but, in my specimen, only scantily pubescent.

The shape of the thorax is somewhat similar to that of *M. laeviceps* and *M. cognatum*, but the elytral sculpture, rather thick legs, and reduction of labral punctures are good distinguishing features.

♂. Length, 25 mm.; breadth, 8 mm.

Mount Quoin, Tararua Range; elevation, 3,900 ft. My specimen, somewhat damaged, was found by Mr. A. O'Connor, of Wellington, who sent it mounted on cardboard.

3168. **Mecodema arcuatum** sp. nov.

Elongate, dull sooty black, legs, antennae, and palpi piceous.

Head rather large, including the mandibles, as long as the thorax, forehead strongly longitudinally striate, more irregularly near the eyes; in line with these there are numerous distinct punctures; labrum curvate in front. Thorax cordate, apex evidently arcuate-emarginate, its sides not distinctly crenulate, curvedly narrowed towards the base but without any abrupt contraction there, lateral margins not unequally expanded, posterior angles obtuse; the disc with feeble transverse striae, but the basal fossae, which are moderately large and placed close to the angles, are more distinctly and irregularly wrinkled, the base is more or less punctate, the curvate frontal impression is well marked throughout and near the angles feebly punctate, the median groove is distinct; length and breadth about equal. Elytra slightly convex, twice as long as thorax, only a little broader, their sides gently rounded, about equally so near the base and apex; the sutural 4 striae on each elytron are only slightly impressed, and rather finely and distantly punctured on the middle, with plane interstices; the 3rd and 5th are a little broader than the others; the 5th and 6th striae are rather more distinctly punctate, and the 7th interstice is somewhat carinate from the base towards the middle; the 7th and 8th striae are deeper and more coarsely but not very regularly punctured; the interval between the 8th stria and the side is smooth.

Legs rather thick, like those of *M. quoinense*, the external angle of the posterior tibiae hardly at all prominent. Antennae pubescent from the 4th joint onwards.

From all the other species, except the very different *M. striatum* (2600), this is distinguished by the more incurved thoracic apex. Castelnau's *M. impressum* is described as having a rather brilliant coppery hue, with the anterior angles of the thorax densely punctate, whilst *M. lucidum* is larger. I do not think that this species will prove to be

identical with either of these. The elytral interstices are not flat in *M. quoinense*.

♀. Length, 23 mm.; breadth, 7½ mm.

Near Martinborough, Wellington. Mr. A. O'Connor. Unique.

Group Anchomenidae.

3169. Ctenognathus simmondsi sp. nov. *Ctenognathus* Fairmair, Ann. Soc. Ent. France, 1843.

Black, moderately nitid, femora infuscate, tibiae, tarsi, antennae, and palpi ferruginous.

Head oviform, constricted behind the prominent eyes, with a pair of setae near each of these, the frontal impressions elongate. Thorax of equal length and breadth, widest just before the middle, well rounded there, strongly sinuate behind, but nearly straight, or extending slightly outwards, near the base, with rectangular posterior angles, lateral margins reflexed throughout; basal fossae large, prolonged forwards as broad marginal channels almost to the apex, so that the disc appears to be on a higher plane; the deep median groove becomes obsolete towards both extremities; the oblique frontal linear impressions are well marked, the transversal discoidal and the longitudinal basal wrinkles are feebly impressed. Elytra oblong-oval, with gradually and regularly rounded shoulders; they are obliquely narrowed but only slightly sinuated apically; dorsum slightly convex, with sharply marked and almost impunctate striae and scutellar striolae; interstices nearly plane, without perceptible punctures.

Antennae elongate, reaching backwards beyond the middle femora. Tarsi elongate, the posterior feebly ridged and bisulcate above.

Nearly related to the Southland *C. littorellus* (2670), which, however, has convex elytral interstices and different thoracic channels. In 1686, *C. adamsi*, the basal fossae are only prolonged as far as the middle of the sides, and the lateral rims are less reflexed.

Length, 11 mm.; breadth, 4½ mm.

Mount Quoin, near Wellington. Found at an altitude of 1,000 ft. by Mr. Hubert W. Simmonds, after whom it has been named.

3170. Tarastethus amplipennis sp. nov. *Tarastethus* Sharp, Man. N.Z. Coleopt., p. 1003.

Nitid, nigrescent, suture and margins of elytra slightly rufescent; femora yellow; tibiae, palpi, and antennae testaceous, the basal joint of these last always so, the following ones sometimes darker; mandibles and labrum piceo-rufous.

Head impunctate, the elongate frontal impression and subocular groove at each side with a cariniform interval. Eyes large, finely faceted. Labrum almost truncate, with 6 setigerous punctures. Thorax about a third broader than long, widest near the middle, rounded there, moderately narrowed and slightly sinuate behind; lateral margins somewhat expanded in front, so that the angles seem obtusely prominent; posterior angles sharply rectangular, usually projecting outwardly; disc moderately convex, nearly perfectly smooth, its central groove not attaining the base or apex; basal fossae large and deep, the interval distinctly punctured, a shallow oblique impression which extends towards the middle, at each side, causes the area near the angle to appear explanate and elevated. Scutellum distinct. Elytra large and convex,

about a third broader than the thorax, with rather broad rounded shoulders; they are very distinctly and regularly striate, but the punctation of the striae is rather fine; each has a short scutellar stria; there is no subapical carina; there is a single puncture, placed before the middle, on the 3rd interstices.

Underside glossy piceous, coxae reddish, the posterior trochanters testaceous. Mesosternum medially convex but not canaliculate, its flanks punctate. Abdomen impunctate, but with some shallow lateral impressions.

The posterior tarsi are simple, but the 4th joint of the other pairs is distinctly longer than the third, with well-developed rather elongate lobes. In the male the basal four joints are slightly dilated, and of about equal width; the 2nd and 3rd are cordiform, but the sexual disparity is hardly perceptible.

Var. *T. labralis*.—Labrum with minutely coriaceous sculpture, but without the least trace of setigerous punctures in front.

Readily distinguishable by the subcordiform, regularly striated hind-body, with unipunctate interstices, but lacking the usual carinae. There is only one ocular seta, and that of the thorax is situated behind the middle of each side.

Length, 6½–7 mm.; breadth, 2⅔–3 mm.

Raurimu. I secured five specimens from under logs in January, 1910, and Captain H. S. Whitehorn, of the Geological Survey Department, during March, collected and forwarded a parcel of forest leaves out of which I picked another. These decayed leaves were gathered near the head of the Retaruke River, near the recently surveyed coalfield.

3171. **Tarastethus phyllocharis** sp. nov.

Convex, glossy, piceo-niger; legs ferruginous; palpi, antennae, and tarsi fulvescent; mandibles and labrum pitchy red.

Head smooth, the frontal impressions rather elongate and deep, so that the broad plica near each eye appears elevated; labrum incurved in front, with 6 setigerous punctures. Thorax a fourth broader than long, the middle widest, well rounded there, moderately sinuate-angustate behind, posterior angles rectangular; disc smooth and convex, the base slightly depressed, distinctly and rather closely punctate, the fossae about equidistant from the sides and middle but not sharply defined, the discoidal groove somewhat expanded behind. Elytra a fifth longer than broad, evidently broader than the thorax, their sides distinctly margined and more rounded at the base and apex than at the middle, the shoulders, however, are rather wider than the base of the thorax; they are seriate-punctate, the inner series, however, almost form striae, the sculpture becomes very much finer and more irregular behind, and the punctures outside the 4th series usually become obsolete near the base; the interstices are broad and plane, and the apical carinae are well developed.

Underside shining; mesosternum convex and deeply channelled in the middle and punctate at the sides; metasternum broadly concave medially; abdomen impunctate, but with shallow foveiform impressions at each side, the terminal segment, at the extremity, has a pair of setigerous punctures on each side of the middle, where it is finely transversely wrinkled.

The thorax is rather shorter and less deeply sinuate towards the base than in *T. puncticollis* (1799), and the whole sculpture differs, and, more-

over, the thoracic setae are absent, though the specimens are quite fresh and uninjured.

Length, 6 mm.; breadth, 3 mm.

Erua, at an elevation of about 2,500 ft. Three were found by myself in January, 1910, and two by Mr. W. J. Guinness, railway station-master, in March, all amongst decaying leaves on the ground. Another was found near the base of Mount Ngauruhoe by Mr. Guinness; and one taken previously by myself at Raurimu, elevation 1,900 ft., has more strongly sculptured elytra than the others.

3172. Tarastethus lewisi sp. nov.

Glossy, aeneo-niger, elytral margins and apices, the legs, antennae, and palpi testaceous, mandibles pitchy red.

Head smooth, reddish in front, interocular impressions elongate, the space between each of these and the lateral groove somewhat elevated. Eyes large, not prominent, finely faceted. Thorax a fourth broader than long, widest near the middle, its sides distinctly margined, moderately rounded, slightly sinuously narrowed behind the middle, posterior angles rectangular; the anterior, though not prominent, are more distinct than usual, owing to the slight dilatation of the lateral margins there; disc moderately convex, smooth, its central sulcus does not attain the apex, the base has duplicate fossae near each side, and the outer one is separated from the lateral margin by a carina. Scutellum distinct, rather broad. Elytra oviform, a fifth longer than broad, widest near the middle, of the same width as thorax at the base, with reflexed margins and rather broad channels; they are moderately punctate-striate, the striae, however, do not reach the base, and, except the sutural pair, become indefinite towards the extremity, and those beyond the 4th are indistinct near the sides; 3rd interstices slightly broader than the contiguous ones and rather coarsely tripunctate, the apical carinae are well developed.

Certain peculiarities are observable in this species. The labrum is remarkable, for in place of being subquadrate, and widely emarginate in front, it is quite conical, and bears an exserted central seta and a pair of finer ones at the sides. The maxillary palpi are finely setose. The inner emargination of the front tibiae is less distinct than usual, so also is the basal margin of the elytra. The surface of the front tarsi is more pubescent. There is only a single ocular seta, and that of the thorax appears to be absent.

Length, 4½ mm.; breadth, 2¼ mm.

Greymouth. Described from a female sent by Mr. J. H. Lewis, whose name has been given to it.

3173. Tarastethus cordipennis sp. nov.

Convex, rather elongate, glossy, nigro-piceous, labrum and mandibles dark red; antennae, palpi, and tarsi testaceous, the legs rather darker.

Head oviform, frontal impressions elongate, and with some fine punctures between them. Labrum quadrate. Eyes nearly flat, indistinctly faceted. Thorax apparently elongate, actually of equal length and breadth, lateral margins distinct, slightly thickened behind, it is moderately rounded at and before the middle, and distinctly sinuate behind, the base nevertheless is about as wide as the apex, with rectangular angles; the dorsal furrow does not extend to the apex or base, which latter is very distinctly punctured right across; the basal fossae are

situated between the middle and the sides, and, owing partly to the punctation, are not very definite. Elytra widest before the middle, a good deal attenuated posteriorly, with the lateral margins well developed to within a short distance of the apices; they are, relatively, strongly seriate-punctate; near the suture, however, they are striate and rather more finely punctured; the apical carinae are not very sharply elevated, and the space between the outer series of punctures and the sculptured marginal channel on each elytron is smooth.

Underside shining black; abdomen uneven, with broadly depressed sutures between its segments, the terminal bipunctate at each side of the middle at the apex.

The rather elongate contour, longish thorax, and the posteriorly attenuated cordiform hind-body are good discriminating characters.

Length, 6 mm.; breadth, 2½ mm.

Mount Quoin, Tararua Range. A single female, from Mr. H. W. Simmonds.

Group Pogonidae.

3174. **Oöpterus laevigatus** sp. nov. *Oöpterus* Guerin, Man. N.Z. Coleopt., p. 54.

Suboblong, slightly convex, nitid; castaneous, femora and elytral margins fulvescent; the tibiae, tarsi, antennae, and labrum more or less rufo-castaneous.

Head smooth, the frontal impressions well marked and extending from the interantennal suture to the middle of the eyes, which are large and moderately convex. Thorax a seventh broader than long, widest at the middle, gently curvedly narrowed anteriorly, gradually, but scarcely sinuously, contracted behind, with rectangular but not acute posterior angles, base truncate, apex slightly incurved, lateral margins rather thin; basal fossae broad and well marked, each separated from the side by a distinct carina, the central groove hardly attains the apex, its whole surface impunctate, but with a few fine striae near the middle of the base. Scutellum subcordate, smooth. Elytra oblong-oval, a little wider than thorax at the base, not quite thrice its length, with broad lateral margins, which, however, become very narrow near the broadly rounded apices; on each elytron there are 4 slightly impressed, impunctate striae; these are obsolete near the base, the sutural alone reaches the apex; the apical plica is distinct, the base is tripunctate but the 3rd interstice is only very feebly so, the side is quadripunctate near the shoulder, the posterior punctures are less definite, there are none at all near the middle.

Tibiae straight, the front pair nearly glabrous, the others finely setose. Tarsi with yellow setae above; the anterior with the basal joint dilated and oblong, the next cordiform, also dilated, yet hardly as broad, the inner angle of both slightly prolonged; 3rd and 4th cordate, evidently smaller than the 2nd, and consequently hardly at all expanded.

In *O. patulus* (1145) the thorax is widest before the middle, and therefore subcordate, and its sculpture is different; the elytra are shorter and more oval, with fine yet quite perceptibly punctured striae, the 3rd interstices are tripunctate, and the coloration is altogether darker.

♂. Length, 6½ mm.; breadth, 2⅔ mm.

Hastwell, near Napier. A single male, found by Mr. H. Suter. This genus was placed by Lacordaire in the *Cnemacanthidae*, by Bates in the *Pogonidae*.

Group Feronidae.

3175. **Trichosternus wallacei** sp. nov. *Trichosternus* Chaudoir, Man. N.Z. Coleopt., p. 31.

Oblong, slightly convex, moderately nitid; black, elytral margins faintly viridescent, legs and antennae rufo-piceous, tips of palpi rufescent.

Head smooth, frontal foveae elongate, with 2 setigerous punctures alongside each eye and the same number on the forehead; labrum transverse, feebly emarginate. Eyes prominent. Thorax subquadrate, a third broader than long, the apex widely incurved, base medially emarginate, lateral margins moderately thick; it is a little broader before the middle (in some examples hardly at all) than elsewhere, gently rounded towards the front, nearly straight behind, posterior angles exactly rectangular; the median sulcus does not reach the apex, and is slightly expanded behind; the basal fossae, situated between the middle and sides, are large, somewhat prolonged laterally, so that the space near each angle seems flattened. Scutellum striate at base. Elytra with dentiform shoulders, just perceptibly broader than thorax at the base, their sides slightly curvate, with well-developed margins, moderately sinuate-angustate near the extremity; their striae are well marked, and become deeper and wider towards the sides and apices, but are rather indefinitely punctured; interstices plane on the middle, convex near the extremity and sides, the 3rd and 5th generally slightly broader than those near the suture, the former tripunctate, the 7th with 5 punctures.

Femora moderately slender; intermediate tibiae with slightly prominent hind angles; tarsi rather slender; the basal four joints of the anterior only moderately dilated.

Underside glossy black, almost quite smooth; the apex of the terminal ventral segment quadripunctate in both sexes.

Female.—Elytral striae very finely but rather more distinctly punctate than in the male.

I have seen a dozen specimens; sometimes there are 4 punctures on the 3rd interstices and 1 on the 5rd, but otherwise they are homogeneous and vary but little in size. The only similar species is *T. hammerensis* (2631).

Length, 21–23 mm.; breadth, 8–8½ mm.

Wairiri, Seaward Kaikouras. It is with pleasure that I name this species after its discoverer, Mr. W. L. Wallace.

3176. **Pterostichus hamiltoni** sp. nov. *Pterostichus* Bonelli, Man. N.Z. Coleopt., p. 31.

Suboblong, narrowed medially, only slightly convex, shining; black, the tibiae, tarsi, and antennae piceo-rufous, palpi paler.

Head, including the prominent eyes, rather narrower than front of thorax, almost quite smooth, with elongate frontal impressions. Thorax widest at the middle, regularly rounded from the obtuse anterior angles to beyond the middle, and from thence considerably, and somewhat sinuously, narrowed towards the well-defined rectangular posterior angles; it is quite a third broader than long; the apex is deeply, the base slightly medially, incurved; the basal fossae are deep, rather elongate, distinctly separated from the sides and more widely from the middle, the mesial groove does not reach the apex, the surface is nearly smooth. Scutellum strongly striate at the base. Elytra more than double the length of thorax, a good deal, yet gradually, narrowed towards the base, the

humeral margins thickened but not projecting, and not exceeding the thoracic angles in width; they are very evidently sinuate behind, the apices, nevertheless, are quite broad and only slightly rounded; they are finely and regularly punctate-striate, interstices plane on the disc, but becoming a little convex near the sides and extremity; the 3rd, 5th, and 7th are slightly broader than the others, the 3rd are tripunctate, and the 7th have about 6 rather large punctures.

Underside shining black; the terminal ventral segment has a broad oblique depression extending from the base to the middle, at each side; the apical portion is a little depressed and distinctly longitudinally strigose, and is bipunctate at each side of the middle, at the extremity.

There are 2 setigerous punctures near each eye, the same number on the forehead; there is one before the middle at each side of the thorax and another at the hind angle.

This belongs to the section composed of *Trichosternus*-like species (see p. 986, Man. N.Z. Coleopt.), but after comparison with its numerous members I fail to find any exactly like it. The unusual sculpture of the last abdominal segment is a good guide to discrimination.

♀. Length, 25 mm.; breadth, 8½ mm.

Bold Peak, Wakatipu; elevation, about 6,000 ft. A single female, named in honour of Mr. H. Hamilton, its finder, whose recent collecting tours have added considerably to our knowledge of the coleopterous fauna of the mountainous regions of the South Island.

Group Anisodactylidae.

3177. **Allocinopus smithi** sp. nov. *Allocinopus* Broun, Ann. Mag. Nat. Hist., ser. 7, vol. 11, p. 607.

Oblong, slightly convex, moderately nitid; rufo-piceous, lateral margins of thorax and elytra more rufescent, labrum and mandibles dark red; the legs and antennae fusco-rufous, but with the basal two joints of these latter and the palpi fulvescent.

Head short and broad, yet rather narrower than the thorax, smooth, with a pair of shallow interantennal foveae; epistome longitudinally striate, and, near each front angle, with a setigerous puncture; there is another one near the back of each eye. Thorax about a third broader than long, its apex widely but not deeply incurved, so that the angles appear slightly prominent; base subtruncate and finely margined; it is a little wider before the middle than elsewhere, moderately rounded there, and rather gradually narrowed towards the rectangular but not acute posterior angles; the lateral margins are well developed, and the channels inside these, through narrow, are a little widened in front; the basal fossae, situated between the middle and sides, are shallow and indefinite, and outside these the surface is slightly flattened, the median groove extends from the basal margin but does not reach the apex, there is no other distinct sculpture. Elytra nearly twice as long as broad, rather wider than thorax at the base, their sides distinctly margined and nearly straight, but widely sinuated and considerably narrowed towards the extremity; their impunctate striae, with the exception of the two sutural, which do not reach the basal margin, are well marked throughout, the short scutellar striae also are distinct; interstices simple and nearly plane, the lateral punctiform impressions are not coarse or deep.

Legs stout, the tibiae fringed inwardly with fine setae, the intermediate with spiniform setae externally; tarsi finely setose above.

Underside shining, the head and breast pitchy red, abdomen nigro-piceous. Metasternum indistinctly granulate. Terminal ventral segment obliquely narrowed towards the extremity, which is subacuminate, with a single setigerous puncture there at each side of the middle. The front and middle tarsi bear elongate setae along their soles, and a spiniform one at the side of the basal four joints.

Male.—Prosternal process with numerous setae at the tip. Metasternum short, with minute granules and setae in the middle. Basal ventral segment at the base, in the middle, finely sculptured and minutely setose, the terminal one distinctly sinuate near the extremity, angulate at the commencement of the sinuosities, the apex itself obtusely rounded and with a pair of setigerous punctures there.

♀. Length, 8 mm.; breadth, 3 mm.

Ratapihipihi Forest, Taranaki. A pair of mutilated specimens were found by Mr. W. W. Smith, whose name has been attached to this species. The discovery of the male is important, as without it I had been unable to determine the genus to which other species belonged.

Obs.—This and the following species will not, I think, remain permanently with *Allocinopus*, as they exhibit certain differences. In both sexes the prosternal process is setigerous. The terminal articulations of the palpi are acute at the extremity instead of being obtuse or subtruncate; the maxillary are finely setose, and the penultimate joint is shorter than the terminal. The rigid setae attached to the mentum are very elongate, so also are the pair at the apex of the ligula. The soles of the male tarsi appear to be without distinct sponge-like vestiture, but my specimen having lost one foot, and as the other is not perfectly free from sappy matter, I do not feel sure on this point.

3178. **Allocinopus castaneus** sp. nov.

Oblong, moderately shining; head and thorax dark castaneous; antennae, legs, and elytra rufo-castaneous, these last paler along the sides near the apices; labrum and mandibles piceo-rufous, palpi fulvescent.

In most respects similar to *A. smithi*. The tips of the terminal joints of the palpi are more pointed, and the 2nd joint of the maxillary more curvate. The forehead is less evidently striate. The anterior angles of the thorax, owing to the very slight apical incurvature, are less prominent, its lateral margins are thinner, and the basal fossae rather more distinct and elongate. The elytra are somewhat more oviform and less acuminate posteriorly. The seta at each side of thorax is placed before the middle, as in the preceding and following species.

Underside wholly piceo-rufous. Prosternal setae numerous, but not coarse. Terminal ventral segment widely sinuate towards the extremity, which is broadly rounded, instead of being subacuminate, as in the preceding species, it is similarly bisetose.

♀. Length, 7–7½ mm.; breadth, 2½–2¾ mm.

Maketu, Hunua Range. Both specimens are females, and were found about twenty years ago, at long intervals, during collecting-tours.

3179. **Allocinopus angustulus** sp. nov.

Castaneo-rufous, shining; the legs, palpi, and basal articulations of antennae fulvescent; remaining joints of these last darker and opaque; epistome, labrum, and mandibles reddish, these last, however, are nigrescent at the extremity.

Head nearly quite smooth. Thorax about a fourth broader than long, not perfectly smooth, having some obsolete longitudinal linear impressions in front and transverse ones on the disc; the mesial sulcus nearly attains the apex; there are no basal fossae, only a broad oblique impression of each side near the angle; its sides are rather slightly, almost regularly rounded, yet rather more straightly narrowed towards the subrectangular basal angles. Elytra with well-marked impunctate striae and short scutellar grooves; they are rather wider than thorax at the base, and a good deal, though gradually, narrowed behind the posterior femora, with only very slight subapical sinuosities.

When compared with *A. smithi* this is seen to be narrower and flatter. The front of the thorax is a little more incurved, so that its angles seem more prominent, but the posterior angles are more obtuse, and the base slightly emarginate medially. The elytra appear to be narrower and longer, and are not at all abruptly narrowed near the extremity; the dorsum is nearly flat, but the sutural region is a little elevated behind.

♀. Length, 8 mm.; breadth, $2\frac{1}{2}$ mm.

Forty-mile Bush, near Napier. A single female, under the number 352, from Mr. H. Suter, had to be set aside for many years until the recent discovery of the male of *A. smithi*.

3180. **Zabronothus major** sp. nov. *Zabronothus* Broun, Man. N.Z. Coleopt., p. 1327.

Oblong-oval, gradually narrowed anteriorly, slightly convex, moderately shining, piceo-niger; legs, mandibles, and labrum pitchy red, the antennae, palpi, and tarsi paler.

Head narrower than thorax, smooth, frontal impressions quite obsolete. Thorax incurved at apex, with obtuse angles, the width at the base nearly a third more than the length in the middle; its sides distinctly margined, nearly straight for two-thirds of the length, being only very slightly and gradually narrowed anteriorly, but near the front rather more curvedly contracted; base medially emarginate and resting on the elytra, with obtusely rectangular angles; the mesial groove starts from the basal margin but does not reach the apex, basal impressions feeble and elongate, placed between the middle and sides. Scutellum triangular. Elytra scarcely any broader than the thorax at the base, humeral angles thickened and projecting outwardly, only very slightly, however; they are a little wider at and behind the middle, and considerably though not abruptly narrowed near the extremity; their striae are simple, narrow, and sharply marked throughout, and become deeper behind; interstices broad and plane; marginal punctures almost absent near the middle.

There is a single setigerous puncture at each side of the thorax before the middle, and another at each hind angle, a pair alongside each eye and on the edge of the forehead, and twice that number at the extremity of the last ventral segment.

Antennae thickly covered with yellow pubescence, and a few slender setae; from the 4th joint onwards, the basal three glabrous; they extend backwards to the shoulders. Labrum transverse. Palpi with acuminate terminal articulations. Eyes moderately large, but not prominent. Legs robust; tibiae with spiniform setae externally, the posterior flexuous.

Considerably larger than the typical species (2333). The general contour is almost uninterrupted from the posterior femora to the front of thorax, which in shape differs from that of the other species.

♀. Length, 11 mm.; breadth, 4½ mm.

Broken River, Canterbury. Described from a single female found by Mr. J. H. Lewis, who also secured the male, which, however, I have not seen.

3181. **Zabronothus aphelus** sp. nov.

Oblong, slightly convex, moderately nitid; black, legs rufo-castaneous, antennae, palpi, and tarsi of a lighter hue

Head subovate, evidently narrower than thorax, without definite frontal impressions. Labrum rufescent, transversely quadrate. Thorax slightly broader than long, apex widely incurved, with obtuse angles; its sides finely margined, gently rounded, very feebly sinuate behind, posterior angles rectangular but not acute, the base widely emarginate and resting on the elytra; the central groove does not attain either the base or apex; the basal fossae are sulciform, only moderately impressed, and are situated midway between the middle and sides; the surface is not perfectly smooth, but there is no obvious sculpture. Elytra oblong-oval, more than double the length of the thorax, and, owing to the slightly dentiform shoulders, rather wider than it is at the base; their sides are finely margined and a little curved; near the extremity they are somewhat rufescent, but scarcely at all sinuate; on each elytron there are 7 impunctate sharply marked dorsal striae; these extend from the basal margin to the apex; interstices simple, broad and plane; the serial punctures between the lateral margin and the 8th stria are nearly absent at the middle.

Manifestly smaller than the other species, most nearly approximated to *Z. oblongus* (3025), but narrower, the thorax less transversely quadrate, with more definite posterior angles, more narrowed in front, and with better-marked basal foveae.

Length, 6½ mm.; breadth, 2½ mm.

Wairiri, Kaikoura. A single damaged male, found by Mr. W. L. Wallace.

Group Aleocharidae

3182. **Aphytopus porosus** sp. nov. *Aphytopus* Sharp, Man. N.Z. Coleopt., p. 1024.

Elongate, moderately nitid; pubescence greyish, fine but distinct, thicker on the elytra than it is elsewhere; head and thorax pale fusco-rufous, elytra light brown, abdomen dark fuscous, legs and basal five joints of antennae testaceous.

Head rather broad, not perceptibly narrower than thorax, finely yet distinctly but not closely punctate. Eyes large, not prominent. Thorax of equal length and breadth, about a third narrower than the elytra, its base rounded, the sides nearly straight; it is moderately closely and distinctly punctured, but without other impressions. Elytra nearly twice the length of thorax, their shoulders rounded, the punctation a little coarser but more distant than that of the thorax. Hind-body elongate, rather finely and distantly sculptured, 5th segment smooth on the middle.

Antennae distinctly pubescent; 2nd joint elongate but stout; 3rd more than half the length of 2nd, with a slender basal stalk; joints 4–8

slightly dilated; 9th and 10th larger, transverse; 11th oviform, not as long as the preceding two combined.

Evidently similar to the typical species (1835), darker, the head not distinctly narrower than the thorax, which is not dull, and has no discoidal impressions. The tarsal structure is precisely alike in both species.

Length, nearly 2 mm.; breadth, ½ mm.

Hunua Range, near Drury. I found one amongst decaying leaves on the ground.

3183. **Aphytopus granifer** sp. nov.

Fuscous, slightly shining, with distinct suberect greyish pubescence, the legs and basal joint only of the antennae testaceous.

Head about as broad as thorax, rather finely but not closely punctured. Thorax narrower than elytra; its sides nearly straight, but somewhat contracted in front, where it is narrower than the head; it is slightly bi-impressed longitudinally from the base to beyond the middle; its punctation is close and moderately coarse. Elytra oblong, hardly double the length of thorax, shoulders a little rounded, the base incurved so as to be adapted to that of the thorax; they are relatively coarsely but not deeply or closely punctated. Hind-body elongate, with very fine, distant, granular sculpture, which, however, is quite definite on the basal segment.

Antennae elongate, finely pubescent, their 2nd joint as long as the 1st and nearly as stout, joints 3–6 about equal, oblong, 7th and 8th a little shorter and broader, 9th and 10th rather broader, 11th about as long as the preceding two together.

The granulation of the hind-body at once distinguishes this from the foregoing species. The 3rd antennal joint is not stalk-like at the base, and the terminal articulation seems unusually large. The thoracic sculpture accords with the description of the type of the genus, as is also the case regarding the peculiar tarsal structure.

Length, 2½ mm.; breadth, ½ mm.

Erua, near Waimarino Plains; elevation, 2,400 ft. Two specimens picked out of leaf-mould which Mr. W. J. Guinness collected for me in April, 1910.

3184. **Aphytopus guinnessi** sp. nov.

Shining, castaneous, legs and basal two joints of antennae testaceous, pubescence greyish.

Head broader than front of thorax, finely but not closely punctured. Thorax seemingly rather longer than broad, curvedly narrowed in front, the base curvate, without definite discoidal impressions, distinctly punctate, not quite as closely on the middle as at the sides. Elytra oblong, evidently broader than thorax, less so at the base, the shoulders being rounded; they are more distantly and less definitely sculptured than the thorax. Hind-body elongate, slightly rufescent at the base, dark fuscous behind, with fine, distant, ill-defined sculpture, not granulate.

Antennae elongate, 2nd joint quite as long as the 1st and nearly as stout, 3rd about as long as the 4th but more slender at the base, 4–7 oblong, 8th slightly shorter and thicker than 7th but not quite as broad as either of the following two, 11th nearly as long as the 9th and 10th conjointly.

Differentiated by the finer sculpture.

Length, 2½ mm.; breadth, quite ½ mm.

Mount Ngauruhoe. Named in honour of Mr. W. J. Guinness, who, in March, 1910, gathered a bagful of decaying leaves, out of which I picked a specimen of this, as well as some other interesting species.

3185. **Calodera wallacei** sp. nov. *Calodera* Mannerheim, Lacord. Hist. des Ins. Coleopt., tom. 2, p. 36.

Elongate, shining, rufescent, hind-body rufo-fuscous but with its terminal segment as well as the legs fusco-testaceous, tarsi and palpi yellow, antennae fulvescent; sparingly clothed with pale flavescent hairs, these are more slender on the anterior parts of the body than on the abdomen.

Head rather larger than thorax, its sides rounded, without perceptible punctation. Eyes large, rather flat. Thorax oviform, of about equal length and breadth, widest at the middle, the base finely margined and slightly rounded, with nearly rectangular angles; the surface minutely, remotely, and indistinctly punctate; at the middle of the base there is a large fossa, from this a shallow linear impression proceeds towards the apex, in some aspects it seems a well-marked groove, in others obsolete. Elytra subquadrate, about a third broader than thorax, distinctly yet rather distantly punctured, with fine sutural striae. Hind-body half of the whole length, parallel, a little narrower than the elytra, its basal four segments strongly margined, each with transverse series of punctiform impressions at the base, 5th minutely and distantly punctured and subtruncate behind. Legs slender, with fine setae, tibiae straight.

Antennae distinctly pubescent, elongate, gradually thickened from the 3rd joint onwards, 2nd and 3rd almost equally elongate but shorter than the 1st, 4th and 5th subquadrate, 7–10 strongly transverse, 11th conical.

C. sericophora (2688) makes the nearest approach in facies, but its head is narrower and less rounded, the eyes are a trifle more prominent, the thoracic groove is deep throughout, and the 3rd antennal joint is shorter.

Length, 3½ mm.; breadth, ⅔ mm.

Wairiri, Kaikoura. Two examples found by Mr. W. L. Wallace, whose name is attached to it.

3186. **Calodera fultoni** sp. nov.

Nitid, castaneo-rufous, labrum, palpi, and tarsi paler; pubescence elongate and slender, flavescent, more scanty on the head and thorax than elsewhere.

Head nearly as large as the thorax, rounded behind the slightly convex eyes, very distinctly and moderately closely punctate; clypeus membranous and pallid. Thorax oviform, as long as broad, its sides rounded, a little wider before the middle than behind, the base finely margined and feebly curved with obtuse angles; its punctation is like that of the head, only slightly finer, the dorsal furrow is distinct and more expanded near the base than in front. Scutellum closely punctate. Elytra subquadrate, broader than the thorax, each with a deep apical sinuosity near the side; with fine sutural striae, their sculpture not quite as close or definite as that of the thorax. Hind-body parallel, narrower than the wing-cases, about as long as the rest of the body, more or less distinctly but not closely punctured, its segments of about

equal length, the 5th truncate at the apex, 6th rounded and paler. Legs elongate, finely setose, tibiae straight.

Antennae nearly as long as the head and thorax, with slender elongate pubescence, 3rd joint of about the same length as the 1st or 2nd, 4th subquadrate, joints 5–10 become more transverse, 11th conical.

In some respects like *C. diversa* (2690); the body and legs more slender, more uniformly coloured, and the elytra without the dense silky yellow pubescence.

Length, 4–4½ mm.; breadth, ⅔ mm.

Taieri, Otago. Three examples from Mr. S. W. Fulton. A specimen, along with some other species, sent to M. Albert Fauvel, of Caen, many years ago was named as above, but, so far as I can ascertain, has remained undescribed.

3187. Myrmecopora funesta sp. nov. *Myrmecopora* Saulcy, Ann. France, 1864, p. 429.

Subopaque, nigrescent, legs and antennae fuscous, mandibles rufescent; head, thorax, and elytra with dense, excessively minute, somewhat coriaceous sculpture; pubescence close, but easily brushed off, greyish, rather short and slender, longer and coarser on the abdomen.

Head about as large as the thorax, subquadrate, posterior angles rounded, with some minute punctures. Clypeus membranous, but not pallid. Labrum transverse, truncate in front. Mandibles thick, curvate and acute at the extremity, with a median inner denticle. Eyes moderately large, longitudinally oval, slightly convex. Maxillary palpi long and stout, penultimate joint thickly pubescent, the terminal aciculate and rather small. Thorax quadrate, rather broader than long, with obliquely rounded anterior angles; the base margined and slightly rounded, with nearly rectangular angles; a more or less evident central groove extends from the apex to the basal fovea. Scutellum triangular. Elytra nearly twice as long and broad as the thorax, quadrate, their apices obliquely curvate towards the suture; with fine sutural striae, somewhat depressed behind the scutellum. Hind-body subparallel, rather narrower than elytra at the base, the basal five segments of about equal length, very finely distantly and indistinctly punctured, 6th segment narrower than 5th, 7th obconical, as broad as the 6th at the base.

Underside opaque, nigrescent, densely and very finely sculptured, thickly covered with slender grey pubescence.

Antennae elongate, reaching backwards nearly as far as the intermediate femora, distinctly pubescent, their basal three joints equally long, joints 4–10 very gradually thickened and abbreviated, the 10th, however, is not perceptibly transverse, 11th oblong-oval, about as long as the obconical 9th and 10th combined.

In M. Fauvel's description* of the Australian *M. senilis*, to which *M. funesta* is closely allied, the frontal pubescence is stated to be of a greenish hue, the thorax not at all transverse, and the basal dorsal segments 2–5 subcarinate along the middle. These characters of themselves are enough for specific discrimination.

Length, 3⅔ mm.; breadth, 1 mm.

Broken River, Canterbury. Discovered by Mr. J. H. Lewis, in December, 1907.

* Hist. nat. les Staphylinides de l'Australie et de la Polynésie, 1879, p. 118.

188. Myrmecopora granulata sp. nov.

Nitid, quite black, legs fuscous, tarsi rufo-fuscous; elytra with very short suberect greyish pubescence; other parts, the hind-body especially, with very few elongate suberect hairs.

Head, in line with the eyes, quite as broad as the thorax, rounded behind, its narrow anterior portion as long as the basal; its punctation rather shallow yet quite distinct, finer and more distant near the antennae. Thorax fully as long as broad, its apical portion, about a third of the whole length, obliquely narrowed so that the front is just about a third of the width of the head; the median basal fossa is well marked, but the longitudinal impression proceeding from it does not attain the apex; it is minutely and distantly punctured. Elytra suboblong, not quite as broad as long, nearly double the length and breadth of the thorax, their punctation close and distinct, rather shallow, and becoming finer and more distant near the sides and base, with fine sutural striae. Hind-body glossy, nearly twice the length of the wing-cases, hardly as wide as they are; basal four segments almost equal, transversely impressed at the base; the first three with indistinct granular sculpture, the granules on the 4th quite definite, on the 5th they are conspicuous, the 6th is retracted in my specimen, its apex is medially emarginate and has granular sculpture.

Antennae elongate, attaining the middle femora, thickly pubescent, 2nd joint elongate yet rather shorter than the 1st or 3rd, joints 4–10 successively though only slightly shortened, the 10th, nevertheless, is nearly twice as long as broad; these 7 articulations are elongate-obconical, and therefore appear subserrate; 11th elongate-oval, rather larger than the 10th.

This, as regards the shape of the thorax, more nearly resembles the unique Australian species so far as can be judged by description alone, but there the likeness ends. The distinct punctation of the head and elytra is very different, whilst the remarkable sculpture of the 5th abdominal segment is very distinctive. *M. fugax*, belonging to Sardinia and Palestine, I have not seen. *M. granulata* is nearly twice the size of *M. senilis*.

Length, 6 mm.; breadth, 1½ mm.

Broken River. A solitary individual sent to me by Mr. J. H. Lewis.

Group Staphylinidae.

3189. Quedius eruensis sp. nov. *Quedius* Stephens, Lacord. Hist. des Ins. Coleopt., tom. 2, p. 84.

Narrow, elongate, head and thorax shining black and slightly bronzed, elytra and hind-body fuscous, the latter often blackish and iridescent; the femora, anterior tibiae, and basal three joints of antennae fusco-rufous or fulvescent; remaining joints dull fuscous; mandibles rufous.

Head oval, rather narrower than thorax, bipunctate behind and also in line with the inner margin of the eyes, and with a smaller setigerous puncture near the front of each eye. Clypeus membranous, not pallid. Labrum deeply emarginate in front. Eyes large, not prominent. Mandibles short. Thorax rather broader than long, gently narrowed anteriorly, posterior angles broadly rounded; with 8 more or less distinct punctures before the middle, and a like number close to the base, but only unipunctate at the sides. Scutellum triangular. Elytra short,

nearly twice as broad as long, their apices oblique towards the suture; they are closely sculptured and covered with yellowish pubescence. Hind-body elongate, 6th segment broadly rounded behind, terminal styles piceo-rufous, the punctation and vestiture resembling those of the wing-cases.

Underside nitid, finely pubescent and punctate, abdomen varying from violaceous to fuscous. Anterior tarsi of the male strongly dilated.

Antennae densely pubescent from their 4th joint onwards, 2nd as long as 3rd, 10th slightly oblong.

Like *Q. aeneiventris* (3035), darker, the hind-body especially, and never with any brassy lustre.

Length, 6–7 mm.; breadth, quite 1 mm.

Erua. Found by myself in January, 1910; also amongst dead leaves collected by Mr. W. J. Guinness in March and April.

3190. Quedius xenophaenus sp. nov.

Elongate, not parallel, nitid; head, thorax, and legs rufo-castaneous, the elytra and hind-body fuscous, the latter somewhat violaceous, antennae infuscate, their basal four joints paler.

Head subquadrate, evenly convex, narrower than thorax, with a pair of minute shallow punctures behind. Eyes rotundate, not prominent, rather small, situated at the sides near the front, with distinct facets. Mandibles moderately elongate, falciform, the right with a large acute inner tooth behind the middle, the left with 4 or 5 denticles. Thorax a third broader than long, gently narrowed towards the truncate apex, with slender lateral margins, posterior angles obtuse but not broadly rounded, with a pair of feebly impressed minute frontal punctures. Scutellum exactly triangular, smooth. Elytra, in the middle, quite twice as broad as long, apices oblique towards the suture, moderately finely and closely sculptured, sparingly clothed with short cinereous pubescence. Hind-body elongate, gradually attenuate posteriorly, with slight elongate impressions or punctures, terminal styles rufo-piceous, its vestiture depressed, elongate and slender, of an ashy colour.

Antennae pubescent, their 2nd joint rather shorter than 3rd or 4th. Forehead truncate between the antennae. Clypeus short and vertical, membranous. Labrum large, testaceous, with 3 frontal notches, so as to be medially bidentate, and bearing some elongate setae. Tarsi pentamerous, basal joints of the anterior only moderately dilated.

Of peculiar aspect, head particularly.

Length, 6 mm.; breadth, 1½ mm.

Waimarino. Unique. Found in January, 1910, at an altitude of 2,700 ft.

Group TACHYPORIDAE.

3191. Lithocharis longipennis sp. nov. *Lithocharis* Lacordaire, Hist. des Ins. Coleopt., tom. 2, p. 94.

Subdepressed, elongate, nitid; hind-body clothed with elongate, suberect, infuscate hairs; the rest of the body very scantily pubescent; head and thorax nigrescent; elytra, legs, and antennae castaneous; tarsi and palpi somewhat fulvescent; mandibles reddish; abdomen dark fuscous.

Head oviform and, including the mandibles, a third longer than broad, the forehead truncate in front, with moderately elevated rufescent antennal tubercles; its punctation distinct, almost coarse, but nowhere very close; in front of the middle there is an obsolete longitudinal im-

pression. Thorax oblong, its length nearly double the breadth, curvedly narrowed in front, its sides nearly straight, posterior angles rounded; it is smooth along the middle, with a shallow linear impression which does not reach the apex; its punctation is a little finer than that of the head, and subseriate near the middle. Elytra oblong, a third longer than the thorax, rather broader than it is; apices obliquely truncate towards the suture, which is sharply defined but without definite striae; their sculpture is rather shallow and subseriate. Hind-body parallel, rather longer but not broader than the wing-cases, 5th segment rather longer than the others, the 6th much smaller and paler, its sculpture indefinite, subgranular.

Antennae elongate, filiform, pubescent; basal joint stout, not much shorter than the following two combined, 2nd shorter than the elongate 3rd, joints 4–10 evidently longer than broad, the terminal elongate-oval, subacuminate, hardly larger than the penultimate.

Maxillary palpi stout, hairy, their 3rd joint gradually incrassate towards the extremity, the terminal minute. Labrum fusco-rufous, large, deeply triangularly impressed in the middle. Legs elongate, anterior femora thick; tibiae finely setose, the posterior thickened near the extremity; front tarsi with strongly dilated basal joints, which, taken together, hardly exceed the slender terminal joint in length.

This species is chiefly remarkable for its elongated thorax and elytra.

♂. Length, 7 mm; breadth, 1⅓ mm.

Westport. Commander J. J. Walker, R.N., before he left New Zealand gave me a specimen, marked 15. Another from Mr. G. V. Hudson, under the number 254, measures 5 mm. by 1 mm., but otherwise accords almost exactly with the above description.

3192. Dimerus whitehorni sp. nov. *Dimerus* Fauvel.

Slender, elongate, slightly transversely convex, nitid; rufescent, legs paler, the antennae, palpi, mandibles, and tarsi flavescent.

Head large, somewhat rounded, broader than thorax, abruptly contracted behind, finely and distantly punctured. Thorax nearly twice as long as broad, widest near the front, moderately rounded there, gradually narrowed backwards, base and apex subtruncate; its surface densely and minutely sculptured, with a few distinct remote punctures and an elongate central fovea. Elytra very short, widest behind, much curvedly narrowed towards the base, which is no broader than that of the thorax, their apices obliquely truncate towards the suture; they are relatively coarsely but not closely punctate, and bear some depressed greyish hairs. Hind-body elongate, parallel, quite half of the whole length, basal segment as long as the elytra, each of the following four slightly narrowed towards the base, the 6th segment transversely quadrate, 7th obconical; the pubescence is pale-yellowish, and the punctation is moderately coarse, but not close.

Underside shining, rufo-castaneous, moderately coarsely punctured, clothed with distinct yellowish hairs. Prosternum with its flanks distinctly marked off by oblique sutures, the coxae situated at its base. Mesosternum longer than metasternum.

Eyes longitudinal, occupying quite half of the whole sides of the head, moderately prominent, with coarse facets. Mandibles as long as the head, falciform, with a very elongate median tooth on the inner side of each. Maxillary palpi not very much shorter than the antennae, the basal joint slender and elongate, the terminal large, elongate-ovate.

Antennae inserted on the sides of the forehead at some distance from the eyes, 10-articulate; basal joint stout and nearly the length of the following two combined, 2nd slightly shorter than 3rd, 6th a little larger than 5th, 7th moniliform and rather smaller than adjoining ones, 9th abruptly enlarged, subquadrate, 10th longer, conical.

Legs elongate, tibiae unarmed; tarsi slender, pentamerous.

Length, 2 mm.; breadth, $\frac{1}{3}$ mm.

Retaruke, near Erua. Four individuals of this extremely slender but interesting beetle were found amongst leaf-mould collected for me in March, 1910, by Captain H. S. Whitehorn, in whose honour it has been named.

Obs.—Many years ago I sent a specimen of the first species I had found to M. Albert Fauvel, of Caen, one of the greatest European authorities on *Staphylinidae*, who named it *Dimerus brouni*. It evidently represented a new genus, but I have been unable to obtain its description. The name *Dimerus* has now been used for one of the *Pselaphidae* by Fiori, and a copy of the diagnosis published in Atti Soc. dei Naturalisti di Modena, 1899, vol. 32, p. 103, is now in my possession, having been written for me by Mr. C. O. Waterhouse at the British Museum.

Group Osoriidae.

3193. **Holotrochus setigerus** sp. nov. *Holotrochus* Erichson, Lacord. Hist. des Ins. Coleopt., tom. 2, p. 113.

Cylindrical, shining; nigrescent; posterior angles of thorax, the labrum, legs, and antennae rufous; sparingly clothed with suberect, slender, yellowish setae.

Head narrower than thorax, with distinct, remote punctures. Eyes minute. Thorax rather broader than long, gradually narrowed anteriorly, irregularly, moderately coarsely and distantly punctate. Elytra twice as broad as long, with a basal impression near each side, their sculpture nearly the same as that of the thorax. Hind-body elongate, distinctly and distantly punctured, 5th segment largest, 7th bispinose at the extremity.

Tibiae straight, the anterior with about 6 minute spines along the outside, intermediate with more, posterior with 2 or 3 only.

Antennae with the 3rd joint rather longer than 2nd, 4th distinctly smaller than 5th, 10th about as long as the conical terminal joint.

Easily recognized by the rather coarse irregular punctation and suberect setae.

Length, $3\frac{1}{2}$ mm.; breadth, 1 mm.

Greymouth. I am indebted to Mr. J. H. Lewis for a specimen.

Obs.—One description I have been unable to get, so it is just possible that the missing one, Dr. Eppelsheim's *H. brachypterus*, may prove to be identical with *H. setigerus*.

Group Oxytelidae.

3194. **Bledius bidentifrons** sp. nov. *Bledius* Leach, Lacord. Hist. des Ins. Coleopt., tom. 2, p. 114.

Elongate, narrow, nigrescent; head, thorax, and elytra rather dull, with greyish setae, those on the elytra suberect and much shorter than the others; hind-body glossy black, and bearing numerous elongate,

conspicuous, flavescent hairs; antennae and legs somewhat infuscate, the tarsi and posterior tibiae testaceous.

Head prolonged and much narrowed anteriorly, with a denticle near each eye just over the point of antennal insertion; it is densely and minutely subgranulate, and, if carefully examined, some fine scattered punctures may be seen. Eyes transversely oval, convex, and very prominent, with coarse facets. Thorax cordiform, rather broader than long, widely emarginate in front, so that the angles seem slightly prominent, its sides moderately rounded near the front, very much so towards the base, so that there is hardly any trace of posterior angles; its sculpture is like that of the head, along the middle there is a glabrous indistinctly marked line. Elytra not closely applied to the thorax, rather longer than it is, subquadrate, with broadly curved apices; their punctation moderately close, rather shallow, and not very distinct. Hind-body nearly double the length of, but quite perceptibly narrower than, the wing-cases, strongly margined laterally as far as the 5th segment, with finely transversely strigose or rugose sculpture; the 6th segment widely, yet slightly, incurved behind; 7th short, rounded; these last with a few fine punctures.

Legs finely setose; tibiae straight, not incrassate; the anterior with 8 or 10 slender spines along the outside, the lower ones most distinct, the second series I fail to detect with any degree of certainty; intermediate with double series of about 5, the posterior tibiae longer than the others, with slender spines below the middle. Tarsi slender, the terminal joint of the hind pair twice the length of the basal two combined.

Antennae geniculate, inserted below the sides of the forehead, finely pubescent; basal joint stout, about half of the entire length; 2nd thicker than 3rd, the 6th rather smaller than adjoining ones; joints 7–9 laxly articulated and broader than preceding ones, 11th narrower than 10th and closely adapted to it.

Maxillary palpi stout, penultimate joint hairy and rather large, the terminal aciculate, but quite easily seen. Mandibles porrect, elongate, rufescent, slightly curved towards the extremity, with a small tooth on the inside before the middle.

Length, 4 mm.; breadth, 1 mm.

Wanganui Beach. Described from a refractory alcoholic specimen forwarded by Professor Chilton, but found by Dr. L. Cockayne. It is no doubt a female, and is the first of this genus discovered in New Zealand. In all the European and Australian species in my possession the head and thorax of the males are furnished with more or less distinct horns.

Group Pselaphidae.

3195. Sagola monticola sp. nov. *Sagola* Sharp, Man. N.Z. Coleopt., p. 134.

Subdepressed, elongate, nitid; pubescence yellowish, slender, and elongate, intermingled with longer erect hairs on the elytra and hind-body; head and thorax red; elytra, legs, antennae, and palpi fulvescent; hind-body rufo-castaneous; tarsi yellow

Head trigonal, dilated and prominent laterally behind so as to be as broad there as the middle of thorax, the median channel extends from the antennal tubercles to the back, where it becomes linear, and there is a narrow basal fovea at each side of it; there are no distinct punctures.

Eyes evidently prominent. Thorax of about equal length and breadth, widest and strongly rounded just before the middle; obliquely narrowed in front, where it is only half the width of the head, with a deep fovea at each side extending from behind the middle to the basal margin, this part therefore is much contracted; the dorsal fovea behind the centre, though large, is not transverse, there is a basal puncture at each side of it. Elytra nearly twice the length of the thorax, gradually narrowed towards yet broader at the base than the thorax, slightly curvedly narrowed behind; sutural striae well marked; the intrahumeral impressions consist each of a basal puncture and a more elongated fovea. Hind-body a third longer than the elytra, indistinctly punctate; the basal three segments broadly margined and of about equal length; the terminal ones, combined, obconical and acuminate, and much paler.

Legs elongate, simple; 2nd tarsal joint distinctly prolonged underneath.

Antennae elongate; basal joint reddish, cylindric, almost as long as the following two together; 3rd longer than broad, but distinctly narrower than the adjoining ones; 4th and 5th equal, longer than broad; 6th slightly shorter; 7th and 8th truncate at the base, a little narrowed apically; 9th and 10th transversely quadrate; 11th conical and acuminate.

When placed alongside *S. eminens* (2724) this species is seen to be less robust, the head is not quite truncate at the base, its hind angles are less prolonged outwardly and are slightly deflexed, the basal foveae are smaller, but the eyes are more prominent; the thorax is narrower and the elytra longer, and, moreover, the dilated hind angles of the head are not concave underneath.

Female.—Genae nearly straight behind the eyes, with obtuse, but not at all dilated, posterior angles; lighter in colour, and with more prominent eyes than the same sex of 2724; the sides of the thorax are less dilated before the middle, and the legs are more slender. On the underside of the head there is a well-marked transverse depression.

Length, 2½ mm.; breadth, ⅔ mm.

Mount Ngauruhoe. A single male and two females found amongst decayed leaves which were gathered for me by Mr. W. J. Guinness.

Obs.—2724 was discovered at Tarukenga, near Rotorua, and I found one male at Waimarino in January, 1909.

3196. **Euglyptus foveicollis** sp. nov. *Euglyptus* Broun, Man. N.Z. Coleopt., p. 1411.

Slender, slightly convex, shining; rufous; elytra, legs, and antennae fulvescent; palpi, tarsi, and terminal joint of antennae flavescent; pubescence greyish, suberect, rather scanty.

Head obliquely narrowed behind, where it is slightly broader than the apex of the thorax; including the large eyes, much wider; it is, proportionally, moderately coarsely punctate, with an indistinct median stria behind, the prominent antennal tubercles separated by a distinct but not wide channel. Thorax slightly longer than broad, widest and obtusely prominent at the middle, more narrowed in front than behind; a transverse impression near the base connects the elongate lateral foveae; the discoidal fovea is elongate, but does not reach the basal impression; its punctation is indistinct. Elytra nearly twice the length of thorax, very little broader than it is at the base, wider near the middle, their

sides gently rounded; they are not perceptibly punctate; the sutural striae are rather fine, but are foveiform and deep at the base; the intrahumeral impression on each is also foveiform, so that the shoulder and the interval between the impression and the sutural fovea appear elevated. Hind-body shorter than the elytra, narrowed and deflexed posteriorly; the 1st dorsal segment horizontal, with a curvate basal depression; it is slightly longer than either the 2nd or 3rd.

Antennae elongate, basal joint thicker but only a little longer than the 2nd, joints 3–5 quite oblong, 6–8 hardly as long as broad, 9th quite double the size of the 8th; 10th evidently broader than 9th, laxly articulated at the base, but closely applied to the 11th, which is large, conical, and acuminate; these 3 terminal articulations bear numerous slender but elongate hairs, and form a well-marked club.

The thoracic sculpture and abbreviated humeral impressions are very different from those of *E. elegans* (2460). On the other hand, it does not agree very well with the type of the nearly allied genus *Microtyrus* (2461). The position assigned to it and the following species is therefore between these genera. There is no other systematic place for them.

Length, $1\frac{1}{2}$ mm.; breadth, $\frac{1}{2}$ mm.

Retaruke, near Erua. Described from a single specimen picked out of decayed leaves collected for me in March, 1910, by Captain H. S. Whitehorn, of the Geological Survey Department.

3197. **Euglyptus longicornis** sp. nov.

Nitid, rufous; elytra, legs, and antennae fulvescent; tarsi and palpi testaceous.

Head rather smaller than thorax, though nearly as broad, coarsely punctate, with a smooth median linear impression behind, and a distinct interantennal channel. Thorax suboviform, widest near the middle, indefinitely punctured; the broad mesial groove extends into the angular fossa near the base; the latter is united to the lateral foveae by a transverse stria. Elytra quadrifoveate, conjointly, at the base, with well-marked sutural striae but abbreviated humeral impressions. Basal dorsal segment with a transverse basal impression; this I consider a generic and not a sexual character.

Antennae stout and elongate, basal joint evidently longer and thicker than the oblong 2nd, 3–5 also oblong, the 4th very slightly shorter than either of the adjoining ones, 6–8 moniliform, 9th distinctly longer than broad; 10th subquadrate, a little stouter than its predecessor, but not at all closely adapted to the base of the 11th, which is large, conical, and acuminate.

Manifestly different from *E. foveicollis;* rather more robust, the eyes less convex, the thoracic median groove not foveiform or shortened, the legs longer, the anterior pair especially, whilst the more elongate antennae, with their laxly articulated 10th and 11th joints, form an additional and easily seen distinctive character.

Length, $1\frac{2}{3}$ mm.; breadth, $\frac{2}{3}$ mm.

Raurimu. I obtained my specimen amongst damp decayed leaves at the bottom of a steep ravine. Owing to the dense vegetation and slippery banks, the descent marked skin and clothing, but did not occupy much time; getting up again loaded with all my collecting gear and mud was a very different affair. I remember the date—28th January, 1910.

3198. Euplectopsis longicollis Reitter. *Euplectopsis* Raffray. *Trichonyx*, Verh. d. naturf. ver. Brunn., vol. 18, p. 4.

Narrow, rufescent, densely clothed with short greyish hairs.

Head somewhat narrower than thorax, much narrowed in front, genae parallel, punctate, with 2 convergent furrows. Thorax somewhat longer than broad, widest before the middle; finely and closely punctate, with 3 foveae near the base, the lateral largest, these connected by a transverse furrow; dorsal groove abbreviated. Elytra distinctly broader than thorax, and almost 1½ times its length, closely but hardly visibly punctured, sutural striae entire, the intrahumeral duplicated. Tarsi with 2 unequal claws.

Antennae with joints 4–8 globose, not oblong, the terminal three abruptly increase, the two penultimate slightly transverse.

Length, 1·8–2 mm.

Greymouth. Mr. R. Helms.

3199. Euplectopsis microcephalus Reitter. *Trichonyx*, Verh. d. naturf. ver. Brunn., vol. 18, p. 5.

Narrow, rufescent, very sparingly pubescent, nitid.

Head small, much narrower than thorax, slightly punctured, with 2 short frontal grooves terminating behind in large deep foveae and convergent in front. Thorax as long as broad, strongly widened and rounded before the middle, finely punctate, trifoveate near the base. Elytra wider than thorax, 1¼ times longer; between the sutural and basal grooves there is a short basal linear impression.

Antennae with joints 4–8 subglobose, the 5th and 7th slightly oblong, the last three abruptly larger, 9th and 10th of equal breadth, transverse.

Like *Trichonyx longicollis*, with a smaller head, deeper frontal fossae, less evidently clothed, more glossy, and of a brighter red.

Length, 2 mm.

Greymouth. Mr. R. Helms.

3200. Euplectopsis brevicollis Reitter. *Trichonyx*, Verh. d. naturf. ver. Brunn., vol. 18, p. 6.

Narrow, rufescent, with silky pubescence.

Head somewhat narrower than thorax, with 2 short subparallel grooves nearly united in front and ending behind in foveae. Thorax somewhat broader than long, narrowed behind, finely punctate, the three basal foveae situated in the transversal furrow, the median longitudinal groove abbreviated in front, in the middle almost foveiform. Elytra similar to those of *Trichonyx microcephalus*.

Antennae with joints 4, 6, and 8 slightly transverse, 5th and 7th quadrate-globose, the two penultimate nearly equal, moderately transverse, 11th large.

Length, 1·3 mm.

Greymouth. Mr. R. Helms.

3201. Euplectopsis rotundicollis Reitter. *Trichonyx*, Verh. d. naturf. ver. Brunn., vol. 18, p. 6.

Narrow, rufescent, with silky pubescence.

Head almost rotundate, very little narrower than thorax, punctulated, bi-impressed in front. Thorax nearly round, with 3 basal foveae situated in the transversal furrow, the intermediate fovea small, discoidal stria

abbreviated, the lateral sulci slightly impressed. Elytra broader and 1½ times longer than thorax. Basal dorsal segment distinctly punctulated, the striolae scarcely visible. Antennae with joints 4–10 globose, transverse, gradually incrassate.

Nearly related to the two preceding species, with shorter, gradually thickened antennae, the head more rounded, lateral grooves of thorax nearly absent, basal dorsal segment distinctly punctulate.

Length, 1·2–1·3 mm.

Greymouth. Mr. R. Helms.

202. **Euplectopsis trichonyformis** Reitter. *Euplectus*, Verh. d. naturf. ver. Brunn., vol. 18, p. 7.

Rufescent, moderately convex, shining, sparsely and finely pubescent.

Head a little narrower than thorax, smooth, with 2 short subparallel grooves united in front, posterior foveae deeply impressed. Thorax almost wider than long, scarcely punctate, discoidal sulcus much abbreviated. Elytra 1½ times longer than thorax.

Length, 1·8 mm.

Greymouth. Mr. R. Helms.

3203. **Euplectopsis schizocnemis** sp. nov.

Elongate, moderately convex, shining; rufo-fulvous, elytra and legs of a lighter hue, tarsi flavescent; with slender yellowish pubescence and some long, erect, slender setae.

Head smaller than thorax, rounded behind the rather small but very prominent eyes, indistinctly punctate, interocular fovae prolonged as far as the elevated and somewhat widely separated antennal tubercles, and with a minute central carina behind. Thorax oviform, slightly longer than broad, more narrowed towards the front than behind, its base a little rounded; it is indistinctly punctured; the median groove is very thin, with sharply defined edges, it assumes the form of a slender carina towards the base, and thus divides the large ante-basal fossa; the lateral foveae are large; the basal margin is minutely asperate, but without well-marked punctures. Elytra but little longer than thorax, rather broader than thorax at the base, a little dilated behind, apices truncate; sutural striae well marked, the intrahumeral impression broad and moderately deep at the base, so that the inner margin and the shoulder seem slightly elevated; there are no perceptible punctiform foveae at the base. Hind-body shorter than elytra, the basal segment with a slight transverse impression, which is limited at each side by a slightly curved carina; 2nd segment, in the middle, fully as long as the 1st; the others deflexed.

Legs elongate, the anterior and intermediate femora arched above and robust, the latter especially; intermediate tibiae shorter than the others, gradually dilated to about double the width of the posterior pair, and, at the extremity, with a deep triangular excision, the protruding inner portion thicker than the outer.

Antennae inserted in deep cavities in front of the eyes, so that the basal joint appears to be no longer or thicker than the oblong 2nd; 3rd obconical, a little longer than broad; joints 4–7 submoniliform, the 6th a little smaller than the others; 8th short and transverse; 9th abruptly enlarged, subquadrate, somewhat oblique at one side in front; 10th transverse, unsymmetrical; 11th largest, ovate and acuminate; the club therefore is evidently triarticulate.

E. eminens (1700) is somewhat similar, but its head is distinctly broader in line with the eyes. It may be at once separated by the coarsely punctate head and thorax and by joints 4–10 of the antennae being more or less strongly transverse.

♂. Length, 2 mm.; breadth, $\frac{2}{3}$ mm.

Retaruke, near Erua. I secured a single male out of leaf-mould kindly collected for me in March, 1910, by Captain H. S. Whitehorn, of the Geological Survey Department, and I secured a female at Erua in January.

3204. Euplectopsis carinatus sp. nov.

Elongate, moderately convex, nitid; rufous; elytra, legs, and antennae lighter, yet not quite fulvescent; tarsi yellowish; pubescence distinct, greyish, very scanty on the head and thorax, the setae outstanding, slender and long; legs also pubescent.

Head smaller than thorax, but, including the very prominent eyes, not much narrower than it is, curvedly narrowed behind; the middle is somewhat depressed as far as the prominent antennal tubercles; there are no well-marked foveae, but the middle of the occiput is elevated, and, when examined in some lights, appears tubercular; the sides are, relatively, coarsely but not deeply punctate. Thorax suboviform, widest near the middle, its smooth anterior portion much narrowed, so that the back of the head exceeds it in breadth; the sides and base have moderately coarse punctures, some of these are encircled by raised margins; the smooth central portion is subcarinate almost from front to base; this carina has a thin, sharply impressed groove, and it divides the large fossa near the base; the lateral foveae are elongate. Elytra subquadrate, broader than the thorax; sutural striae well marked, intrahumeral impressions deep at the base, the interval between each and the suture seems slightly raised half-way along each elytron; there are no distinct basal punctures. Hind-body shorter than elytra, the slight transverse impression in front of the basal segment has curvate external margins.

Legs elongate; front and middle femora very thick and arched above; intermediate tibiae shorter than the others, gradually yet considerably expanded, with a short notch at the middle of the extremity.

Antennae with distinct pubescence; their 2nd joint equals the visible portion of the 1st; 3rd obconical, a little longer than broad, smaller than 2nd; joints 4–8 short, 6th and 8th rather smaller than 7th; 9th abruptly enlarged, broader than long; 10th transverse, slightly broader but shorter than 9th; 11th quite as long as the preceding two taken together, conical, acuminate.

This must be placed near *E. eminens* (1700), which differs in having less-prominent eyes, and thicker, shorter, differently formed antennae, &c.

♂. Length, $1\frac{3}{4}$ mm.; breadth, $\frac{2}{3}$ mm.

Mount Te Aroha. One, found by myself. A second specimen is most likely the female, but it is almost wholly pitchy red; the anterior femora are as thick as those of the male, and the terminal joint of the antennae is similarly prolonged and acuminate.

3205. Euplectopsis antennalis sp. nov.

Elongate, moderately convex, shining; fusco-rufous, the elytra, palpi, and terminal joint of antennae fulvescent, tarsi testaceous; head and thorax sparingly, elytra and hind-body thickly, clothed with flavescent hairs and slender elongate setae.

Head evidently smaller than thorax, rounded behind, yet broader there than the thoracic apex; basal fossae indistinct, the broad median depression extends forwards between the prominent antennal tubercles; the sculpture indefinite, consisting apparently of small granules with a minute puncture in each. Eyes moderately large and prominent, with coarse facets. Thorax suboviform, of about equal length and breadth, rather wider before the middle than elsewhere, rounded there, a good deal narrowed anteriorly; the mesial longitudinal sulcus is well marked, and ends in the basal fossa, which is joined to the elongate fovea at each side by distinct grooves; its sculpture is like that of the head. Elytra a third longer than thorax, rather broader than it is at the base, with rounded shoulders; apices slightly oblique towards the suture, with minute distant sculpture; sutural striae deep, intrahumeral impressions short, each elytron tripunctate at the base, the punctures, however, are in the striae. Hind-body shorter than the elytra, its basal three segments nearly equal, the 1st with a deep transverse basal impression, with carinate sides, the 2nd with a similar but more linear impression.

Legs elongate; anterior femora thicker than the others; tibiae unarmed; all moderately arched outwardly, the front pair with more conspicuous pubescence near the extremity.

Antennae stout, bearing rather elongate pubescence; their 2nd joint almost oval, as thick and long as the uncovered portion of the basal; 3rd nearly as long as broad, bead-like; joints 4–6 transverse, differing but little; 7th and 8th abruptly broader, unsymmetrical, thinner at the inner than at the outer sides; 9th and 10th transverse, still more enlarged, but not double the breadth of the preceding pair, both broad at the base but much narrowed in front; 11th conical, as broad as the 10th, but not as long as the 9th and 10th combined; at its base, on the inside, there is an obtuse tubercle.

There is no necessity for comparison with other species, as the very remarkable antennae are abundantly distinctive

♂. Length, 2 mm.; breadth, $\frac{2}{3}$ mm.

Mount Ngauruhoe. One individual, picked out of a bagful of decaying leaves sent to me by Mr. W. J. Guinness in March, 1910.

3206. **Euplectopsis eruensis** sp. nov.

Elongate, moderately convex, nitid; rufous; legs and antennae paler, tarsi flavescent; pubescence greyish-yellow, suberect.

Head evidently smaller than thorax, nearly straight behind the small eyes, a little uneven and slightly asperate, but without well-marked foveae or punctures. Thorax suboviform, a little broader just before the middle than it is elsewhere, rather longer than broad, indistinctly punctate; median sulcus narrow, sharply marked, extending into and dividing the basal fossa and becoming cariniform at the base; lateral foveae large, each with a slight groove uniting it to the basal fossa. Elytra subquadrate, not exceeding the thorax in length, curvedly narrowed near the base; sutural striae deep and foveiform at the base, intrahumeral impressions also deep at the base but shallow towards the middle. Hind-body as long as the elytra, the basal two segments horizontal, 3rd slightly deflexed and shorter than 2nd, the 1st visible segment medially flattened towards its base, and with a pair of curved carinae there.

Legs moderately stout, anterior femora thicker than the others, all the tibiae slightly dilated and curved below the middle.

Antennae with slender pubescence, their oblong 2nd joint not quite as stout but about as long as the 1st; 3rd obconical, slightly longer than broad; joints 4–6 bead-like, and of about the same length and breadth; 7th and 8th slightly larger, narrowed towards the apex; 9th and 10th rather larger, both narrowed apically; 11th largest, conical, subacuminate.

Underside shining, with suberect greyish pubescence. Head studded with minute but quite definite granules, and bearing erect slender setae. Prosternum medially carinate. Anterior femora broadly grooved, all distinctly pubescent. Metasternum unimpressed. Abdomen elongate; basal segment but little exposed, fringed behind; 2nd and 3rd about equal, each longer than 4th or 5th; 6th finely and distantly punctured, in the middle nearly double the length of the 5th, with a slender basal margin, and, at the apex, with a median semicircular carina.

At once separable from *E. heterarthrus* by its 2nd antennal joint being thinner than the 1st.

Length, $1\frac{2}{3}$ mm.; breadth, quite $\frac{1}{2}$ mm.

Erua. The typical specimen was found by me in January, 1910, and two or three others were picked out of leaf-mould collected two months afterwards by Mr. W. J. Guinness. In two of these specimens the 9th and 10th joints of the antennae are more transversal and not distinctly narrowed apically—possibly a sexual disparity only.

3207. **Euplectopsis heterarthrus** sp. nov.

Elongate, slightly convex, nitid; castaneo-rufous; legs and terminal joint of antennae fulvescent, tarsi and palpi flavescent.

Head evidently smaller than thorax, nearly straight behind the small but prominent eyes, longer and more narrowed in front of them; the foveae small, and situated near the eyes, its surface somewhat asperate or punctate, nearly smooth behind, antennal tubercles small and distant. Thorax oviform, rather longer than broad, its sides moderately rounded, widest at the middle, without distinct punctation; mesial groove narrow, yet definite, and extending into the basal impression, which has a thin groove connecting it with the large fovea at each side. Elytra not much longer than thorax, a good deal broader behind, the shoulders curvedly narrowed so that the base, which is incurved, is hardly wider than that of the thorax; they are only very indistinctly punctured; the sutural striae are broad; the dorsal impression also is broad, deep at the base, but becoming shallow behind, and is marked off from the side of the elytron and the sutural stria by raised lines. Hind-body about as long as elytra, the basal two segments horizontal, 3rd slightly deflexed, the 1st with a transverse impression at its base.

Legs moderately stout, the tibiae slightly curved outwardly, the front and middle tarsi rather thicker than the slender posterior pair.

Antennae stout; 2nd joint suboviform, scarcely longer than broad, rather thicker than the basal; joints 3–5 transverse, quite as broad as 2nd; 6–8 transverse, each becoming shorter than its predecessor; 9th rather broader than 8th, but very short; 10th distinctly enlarged, also tranverse; 11th largest, conical. Maxillary palpi with broadly ovate terminal articulations.

Underside chestnut-red, rather sparingly but evenly clothed with greyish pubescence. Prosternum medially carinate.

Male.—Abdomen elongate, 1st segment ciliate behind, only slightly exposed, 4th rather shorter than 2nd or 3rd, 5th widely incurved at the apex, the 6th more deeply, 7th small.

Female.—5th segment nearly truncate at the extremity, 6th not abbreviated.

This small species may be identified by the antennal structure and *zealandius*-like elytral striae.

Length, 1½ mm.; breadth, ½ mm.

Erua and Raurimu, January, 1910. Three or four specimens were also found amongst leaf-mould collected at Makatote by Mr. W. J. Guinness, and at Retaruke by Captain H. S. Whitehorn, in March.

3208. **Euplectopsis biimpressus** sp. nov.

Elongate, nitid; pubescence yellowish, nearly suberect on the elytra; rufous, legs and antennae paler, tarsi and palpi flavescent.

Head smaller than thorax, straight behind the prominent eyes, punctate and slightly asperate, the foveae somewhat prolonged anteriorly, antennal tubercles rather small and distant. Thorax oviform, slightly longer than broad, the middle widest, more gradually narrowed towards the front than behind; it is less distinctly punctate than the head, the discoidal groove is distinct and extends into but not beyond the basal fossa, which is connected with the large lateral foveae. Elytra rather longer than thorax, curvedly narrowed towards the base, indistinctly punctate; the sutural and interhumeral striae broad and deep at the base, separated by slightly raised lines. Hind-body rather longer than elytra; 3rd segment quite as long as the 2nd, and only slightly deflexed; basal segment with a deep transverse impression in front, the 2nd similarly but less deeply impressed, both of these impressions without cariniform margins. Antennae stout, their 2nd joint slightly thicker than the 1st, quite as long as it is broad; 3rd slightly larger than the shorter 4th, neither quite as broad as the 2nd; 5th distinctly broader than adjoining ones; 6th and 7th transverse, broader than the shorter 8th; 9th and 10th transverse, the latter evidently larger than the 9th, and as broad as the large, conical, terminal joint.

The rather narrower outline, enlarged 5th antennal joint, and the additional impression on the 2nd dorsal segment will aid in its separation from *E. heterarthrus*.

Length, 1⅔ mm.; breadth, ½ mm.

Raurimu. I obtained my specimen in January, 1910, at the bottom of a steep ravine.

3209. **Pycnoplectus cephalotes** Reitter. *Euplectus*, Verh. d. naturf. ver. Brunn., vol. 18.

Rufescent, shining, very finely pubescent.

Head large, transversely quadrate, as broad as thorax, frontal foveae subparallel, united in front, apex deeply foveolate. Thorax with the discoidal sulcus much abbreviated in front. Elytra with the sutural striae entire, the dorsal very short and broad, and with 2 punctiform foveae at the base. Basal three dorsal segments almost equal, the 1st simple.

Very like *Euplectus erichsoni*. The head larger and more quadrate, with shorter frontal furrows opening out into larger grooves behind. Thorax wider, the median groove sharply impressed.

Length, 2 mm.

Greymouth. Mr. R. Helms.

3210. Vidamus calcaratus sp. nov. *Vidamus* Raffray.

Robust, moderately convex, nitid; rufous; legs, antennae, and palpi fulvescent; clothed with slender erect yellowish-grey pubescence, and also with a few elongate erect hairs.

Head large, as broad as thorax, rounded near the base, with a pair of large basal fossae which are prolonged as broad channels and unite in front; antennal tubercles prominent, confluent on the forehead. Eyes convex, rather small. Thorax convex, widest near the front, rounded there, gradually narrowed backwards; with a large transversal depression behind the middle, and a large elongate fovea at each side, these are without any connecting grooves, there is no discoidal sulcus along the middle, near the basal margin it is tripunctate. Elytra rather broader than thorax at the base, nearly twice its length, gradually widened posteriorly, apices truncate; sutural striae deep, intrahumeral impression deep near the base, becoming narrow and shallow towards the middle; each elytron quadripunctate at the base. Hind-body much shorter than elytra, its basal three segments of about equal length, the others deflexed.

Legs elongate; femora stout, the middle pair slightly arched above and thicker than the others; intermediate tibae shorter and stouter than the posterior, with a thick spiniform process near the inner extremity.

Antennae finely and sparsely pubescent; basal two joints cylindric, the 1st rather longer and thicker than the 2nd; 3rd as long as 2nd, more slender, gently narrowed towards its base; 4th and 5th equal, evidently longer than broad; 6th and 7th differ but little from the preceding pair; 8th rather smaller than adjacent ones; 9th slightly broader and longer than its predecessor, but not as broad as the moniliform 10th; the terminal largest, ovate; the club therefore is not distinctly triarticulate.

In Sharp's *Euplectus convexus* (254) the posterior tibiae are subangulate inwardly at the middle. In my *V. spinipes* (3048) the legs are less robust, and the intermediate tibiae have the spine on each placed between the middle and extremity.

♂. Length, 2½ mm.; breadth, nearly 1 mm.

Makatote. A single male found in leaf-mould collected for me by Mr. W. J. Guinness in February, 1910.

3211. Vidamus incertus Reitter. *Euplectus*, Verh. d. naturf. ver. Brunn., vol. 18, p. 8.

Subdepressed, fusco-testaceous, rather shining.

Head not at all narrower than thorax, smooth, frontal furrows narrowed, joined in front, posterior fovae deeply impressed. Thorax as long as broad, without discoidal groove. Elytra broader and 1½ times longer than thorax, very finely punctulated, sutural striae entire, the intrahumeral foveiform.

Male.—Femora moderately incrassate. Metasternum slightly foveate behind.

Similar to *Euplectus karsteni* in size and form. Head smooth, with convergent frontal furrows.

Length, 1–1·1 mm.

Greymouth. Mr. R. Helms.

3212. Plectomorphus optandus sp. nov. *Plectomorphus* Raffray.

Robust, elongate, convex, shining; rufous, elytra and legs of a paler tint, tarsi and palpi fulvescent; pubescence yellowish, thicker on the wing-cases and hind-body than elsewhere, and bearing also some elongate, slender, erect setae.

Head large, rather elongate, narrower than thorax, a little curvedly narrowed behind the prominent, coarsely faceted eyes; with a pair of basal foveae, its whole central portion depressed, so that the antennal tubercles appear large and elevated. Thorax large, cordiform, of about equal length and breadth, somewhat dilated and rounded near the front, where it is more abruptly narrowed than towards the base; the median groove is deep and broad, and terminates in the large post-median fossa, which has thick raised hind borders, and a slight transverse stria towards each side; the lateral foveae are sulciform, and extend from the base to near the front; like the head, it is only indistinctly punctate. Elytra a third longer than thorax, rather broader than it is at the base, more so behind; sutural striae well marked, foveiform at the base, intrahumeral impressions also deep at the base, rather broad, but becoming obsolete towards the middle. Hind-body about as broad as but shorter than the elytra, gradually deflexed, 3rd segment, in the middle, as long as the 2nd; the basal has a deep transverse impression with cariniform lateral borders.

Antennae with slender, elongate pubescence; 2nd joint quite as long but not as stout as the 1st; 3rd elongate, yet shorter than its predecessor; joints 4, 6, 7, and 8 moniliform, each of about equal length and breadth; 5th longer than contiguous ones; 9th and 10th evidently larger than 8th, about equal, truncate at the base, much contracted apically; 11th largest, conical and acuminate; the club therefore is distinctly triarticulate.

Legs elongate; anterior and intermediate femora stouter than the posterior; front tibiae slightly bent and distinctly pubescent near the extremity, the intermediate with a stout though rather short and not very prominent calcar, directed backwards, at the inner extremity.

Differentiated by the rather narrow, medially concave head, and large, elevated antennal tubercles. In the type of the genus, *P. spinifer* (2476), the calcar of the middle tibiae projects inwardly.

♂. Length, $2\frac{1}{2}$ mm.; breadth, $\frac{3}{4}$ mm.

Erua. One male, taken out of leaf-mould, January, 1910. A second, rather more slender, with simple tibiae, is no doubt the female, and was found amongst dead leaves collected by Mr. W. J. Guinness two months afterwards.

3213. Plectomorphus longipes sp. nov.

Elongate, slightly nitid; fusco-rufous, tarsi and palpi fulvescent; its clothing a mixture of rather short, depressed, and more elongate, suberect, greyish hairs, these latter predominate on the elytra; there are also a few slender outstanding setae.

Head nearly as large as thorax, rather abruptly narrowed in front of the eyes, rounded behind them; its sculpture ill-defined, apparently minutely granular at the sides near the front; there is a slender carina along the middle of the occiput, the large basal foveae are not deep, and are not distinctly prolonged anteriorly, the space between the prominent antennal tubercles is depressed. Eyes small, only slightly convex. Thorax cordiform, about as long as broad, strongly rounded, and widest

before the middle, more narrowed in front than behind; the median groove is deep and extends into the basal fossa, which is united to the elongate lateral impressions by transverse striae, its sculpture seems to be finely subgranular. Elytra, at the base, broader than thorax, a third longer, without perceptible punctation; sutural striae deep; dorsal impressions deep at the base, rather broad, but becoming indistinct before the middle. Hind-body deflexed posteriorly, much shorter than elytra, its first visible segment horizontal, with a transverse basal impression.

Legs very elongate, the frontal pairs particularly; femora rather slender, anterior tibiae moderately curved externally.

Antennae elongate, with slender pubescence, basal joint cylindric, stout, red, distinctly punctate, nearly double the length of the oblong 2nd; joints 3–8 oblong, 3–5 slightly larger than the three which follow; 9th and 10th about equal, as long as they are broad, narrowed apically, distinctly, yet not very much, broader than the 8th; terminal elongate, conical, acuminate, and about as long as the 9th and 10th combined.

The remarkably elongate, *Byraxis*-like legs, rather short deflexed hind-body, suberect elytral vestiture, and the peculiar sculpture of the head and basal joint of the antennae are sufficiently distinctive.

Length, 2½ mm.; breadth, ¾ mm.

Greymouth. A single individual from Mr. J. H. Lewis.

Byraxis Reitter. Beitrage zur Kafer-fauna von N.Z. Verh. Nat. ver. Brunn., vol. 20.

Near subgenus *Reichenbachia.* Body rather short and convex. Antennae 10-articulate, robust, distant at base, almost biclavate. Maxillary palpi quadriarticulate, terminal joint fusiform, narrow. Basal joint of posterior tarsi short, the following two much elongated, with single claws. Head obsoletely bifoveolate. Thorax smooth, not at all foveolate. Elytra without dorsal striae.

3214. **Byraxis monstrosa** Reitter. Verh. d. Naturf. ver. Brunn., vol. 20, p. 197.

Rufo-castaneous, shining, smooth; extremity of antennae piceous, legs red.

Head nearly quadrate, almost plane, with 2 shallow frontal foveae. Thorax about as long as broad, cordiform, smooth. Elytra smooth, without dorsal grooves, sutural striae very fine.

Male.—Antennae robust; basal joint stout, cylindric; 2nd quadrate, narrower than 1st; joints 3–8 transversal, 7th and 8th appreciably widened; 9th and 10th large, uneven, and pubescent, the former acutely produced outwardly, the latter very thick, nearly sublunate inwardly, so that the extremity of the 9th joint can be received in the hollow.

Penultimate ventral segment deeply impressed, the basal strongly foveolate medially, crested and bifasciculate laterally.

Length, 1·5 mm.

Greymouth. Mr. R. Helms.

3215. **Byraxis rhyssarthra** sp. nov.

Smooth, shining, nearly glabrous, there being only a few inconspicuous greyish hairs on the hind-body; rufous; elytra, legs, and antennae of a paler red; tarsi and palpi flavescent.

Head nearly as large as thorax, obsoletely bifoveolate in front. Eyes slightly prominent, with coarse facets. Thorax of about equal length and breadth, widest just before the middle, finely margined and feebly bisinuate at the base, without impressions. Elytra nearly thrice the length of thorax, slightly broader at the base, their sides a little rounded near the hind thighs, with fine sutural striae. Hind-body deflexed, without well-marked sculpture. Legs slender.

Underside nitid, rufous, with some fine greyish pubescence. Metasternum broadly medially depressed, the sides of the depression somewhat elevated backwards. Basal ventral segment large, flattened behind, with a distinct tubercle close to each of the coxae; segments 2–4 very short in the middle, the 5th with a large fovea. Anterior trochanters spined.

Antennae 10-articulate; basal joint stout, cylindric; 2nd similar, but shorter; 3rd rather smaller than 2nd, and narrowed towards the base; 4th somewhat moniliform, and shorter than adjoining ones; 5th subquadrate; these articulations bear slender pubescence only; the 6th and 7th coalesce and are hardly distinguishable from each other, except that the latter has short yet distinct brassy setae and is slightly obtusely bulging at one side; 8th extremely short, sometimes overlapped by its predecessor, all three rather broader than the 5th; 9th very large, straight inwardly, longer and gradually becoming broader outwardly, its front angle slightly curved and clasping the base of the 10th, its apex oblique and slightly concave; 10th conical when exserted, subrotundate when closely applied to the penultimate, nearly as broad as it is; both of these bear finer setae than the 7th and are finely but quite definitely granulate.

Malformation of joints 6–8 of the antennae renders an accurate description of one male inapplicable to the other. It must be placed next to 1645.

Female.—Antennae 11-articulate, joints 1–5 like those of the male, their 6th joint of about the same size as the 4th, joints 7–9 transverse, 10th broader than 9th, 11th nearly twice as long as broad.

Length, $1\frac{1}{2}$ mm.; breadth, $\frac{2}{3}$ mm.

Mount Pirongia. I found two males and three females in December, 1909.

Group Silphidae.

3216. **Choleva caeca** sp. nov. *Choleva* Latreille, Man. N.Z. Coleopt., p. 151.

Oblong-oval, nitid, pubescence depressed, slender, pale flavescent; fusco-castaneous, head and legs rufescent; tarsi, palpi, and basal three joints of antennae testaceous, remaining joints fuscous.

Head small, widest and somewhat angulate behind the middle, narrowed anteriorly, moderately coarsely but not closely punctured. Thorax large, the breadth nearly double the length, much curved anteriorly, base truncate but with its angles slightly overlapping the shoulders; it is much more finely punctate than the head, indistinctly on the middle. Scutellum triangular. Elytra nowhere broader than the thorax, and quite twice its length, gradually narrowed posteriorly, the apices not at all acuminate; with fine sutural striae, and moderately close, transversely strigose sculpture.

Antennae as long as head and thorax, gradually incrassate, finely pubescent; 2nd joint rather longer than 3rd; 4th and 5th longer than

broad; 6th subquadrate and a little smaller than 7th, both slightly narrowed towards the base; 8th very short and transverse, but as broad as the 9th, which, as well as the 10th, is transversely quadrate; 11th conical, larger than the preceding.

Tibiae setose, the intermediate curvate, the posterior distinctly bispinose at the extremity. Tarsi elongate, thickly pubescent, the anterior not dilated

The eyes are not discernible above. Maxillary palpi with the penultimate articulation obconical and rather large, the terminal small and acuminate.

Most nearly resembles 2754 and 2756; both of these, however, can be easily distinguished by their prominent eyes.

♀. Length, 2½ mm.; breadth, 1⅓ mm.

Mount Ngauruhoe. My specimen I owe to the kindness of Mr. W. J. Guinness, who collected the leaf-mould it was found in.

3217. **Choleva castanea** sp. nov.

Oblong-oval, slightly convex, a little nitid; light castaneous, the legs, antennae, and palpi somewhat fulvescent; pubescence slender, decumbent, yellowish-grey.

Head trigonal in front, much narrowed behind, acutely angulate laterally at the middle, finely and distantly punctured. Eyes invisible. Thorax large, twice as broad as long, curvedly narrowed towards the depressed and obtuse anterior angles, the base subtruncate but with its angles directed backwards so as to clasp the shoulders, its sculpture fine and rendered indefinite by the pubescence. Scutellum triangular, rather indistinct. Elytra of the same width as thorax at the base, gradually narrowed posteriorly; with fine sutural striae, so sculptured as to appear covered with transverse series of minute impressions.

Antennae with the basal three joints cylindric and about equally elongate; 4th distinctly shorter than 3rd, and as long but narrower than 5th; 6th and 7th subquadrate, the latter evidently the larger; 8th short, nearly as broad as the adjoining ones; 9th and 10th transverse, each narrowed towards its base; 11th larger, conical. Maxillary palpi elongate, penultimate articulation long and broad, the terminal minute and acuminate. Tibiae finely setose, the intermediate arcuate, bispinose at the extremity. Tarsi of the male with the basal four joints of the anterior dilated, the middle pair slightly thicker than the posterior.

Rather less oblong than *C. caeca*, and at once separable by the finer sculpture, of the head particularly, by the more slender posterior tarsi, and the paler and more uniform coloration.

♂. Length, 2⅓ mm.; breadth, 1¼ mm.

Retaruke, near Erua. A single male, picked out of leaf-mould collected by Captain H. S. Whitehorn, of the Geological Survey Department, March, 1910.

3218. **Camiarus estriatus** sp. nov. *Camiarus* Sharp, Man. N.Z. Coleopt., p. 148.

Suboblong, slightly convex, nitid, nigrescent, legs and antennae obscure rufous, pubescence distinct.

Head small, smooth, with a few very slender greyish hairs. Eyes prominent. Thorax a third broader than long, widest near the middle, well rounded and much narrowed anteriorly, slightly sinuate-angustate

towards the rectangular hind angles; the deep median channel, which is expanded behind, extends almost, or quite, from base to apex; at each side of it, on the middle, there is a well-marked puncture, and a smaller one near the apex; basal fossae deep and moderately elongate, with a transverse series of 6 punctures between them; along each side from the posterior angle to beyond the middle there are several small punctures; it bears numerous elongate ashy hairs. Elytra oblong-oval, with curvedly narrowed shoulders, so that the base is only a little broader than that of the thorax, which is hardly half their length; their sculpture is irregular, consisting of, on each, 6 dorsal rows of very unequal punctures, some are elongate or oblong and others very distant from each other, just at the base some almost form striae; they are clothed with suberect, very elongate, slender cinereous hairs, and many conspicuous white ones are intermingled.

Antennae stout, finely setose; the basal six joints are subcylindric, and differ but little, the 1st, however, is thicker, and the 6th rather thinner than the contiguous ones; 7th rather broader than 6th; 8th evidently the smallest; joints 9–11 about as broad as the 7th.

Male.—Tarsi anterior, with the basal three articulations dilated, the 1st largest, intermediate pair simple, 5th ventral segment incurved at the apex.

Rather larger than *C. thoracica* (270), which, however, can be easily recognized by the very regularly striate-punctate elytra and well-marked interstices.

I possess eight specimens of the present species; two were secured by myself, the others were found in leaf-mould sent to me by Mr. W. J. Guinness during March and April, 1910. They are very homogeneous.

Length, 4½ mm.; breadth, nearly 2 mm.

Erua, near Waimarino; altitude, 2,500 ft.

3219. Silphotelus obliquus sp. nov. *Silphotelus* Broun, Ann. Mag. Nat. Hist., ser. 6, vol. 15, p. 83.

Glossy, oblong-oval, slightly convex, bearing only a few minute erect grey setae; fuscous; sides of thorax and the shoulders of a paler and more rufescent hue; the sides of elytra behind the middle fusco-testaceous.

Head slightly broader than apex of thorax, very evidently and broadly depressed between the vertex and the eyes, without visible sculpture. Eyes nearly flat, occupying more than half of each side of the head, just free from the thorax, truncate behind, narrowed anteriorly, with moderate facets. Thorax transverse, the sides very distinctly margined, gently curvedly narrowed towards the subtruncate apex; the base closely adapted to the elytra, feebly medially curved and sinuate towards the sides, its angles just rectangular; its sculpture very fine and hardly discernible. Scutellum large, curvilinearly triangular. Elytra oblong, just a little broader than thorax at the base, quite twice its length, oblique towards the obtuse apices, the lateral margins much thinner than those of the thorax; their punctation irregular, rather fine and shallow, nowhere close, the suture sharply defined, with obsolete striae.

Antennae inserted at the sides quite clear of the eyes; basal joint cylindric, slightly longer than 2nd, both fusco-testaceous; 3rd more slender than 2nd, and nearly as long as it is; joints 4–7 longer than broad, and about equal; 8th slightly broader than 7th, not abbreviated;

10th transverse, shorter and broader than 9th; terminal largest, subrotundate.

Body winged. Pygidium covered. Tarsi seemingly only 4-jointed, but I think they are pentamerous, with the true basal articulation small and indistinctly marked off; the basal three joints of the front pairs are slightly dilated.

The large scutellum and oblique posterior portion of the elytra distinguish it from 2757, the typical species.

Length, 1½ mm.; breadth, 1 mm.

Greymouth. A single individual, from Mr. J. H. Lewis, October, 1909.

Group Colydiidae.

3220. Syncalus explanatus sp. nov. *Syncalus* Sharp, Man. N.Z. Coleopt., p. 200.

Convex, oblong-oval, subopaque; fusco-piceous, the front and sides of thorax, as well as the legs, obscurely rufescent; tarsi and antennae of a paler red; the setae yellowish, rather fine, erect along the sides, on the after part of the body, and on the tibiae; on the elytra, near the suture, they are depressed and fine, but beyond are irregularly concentrated, without, however, forming distinct tufts.

Head with subgranular sculpture, resembling short rugae behind. Thorax nearly twice as broad as long, disc transversely convex, the sides explanate or flattened, slightly rounded and more narrowed in front than behind; the anterior angles extend as far as the front of the eyes, the posterior are nearly rectangular; disc a little uneven, with irregular sculpture consisting of an admixture of small flattened granules and short rugae. Elytra of the same width as thorax at the base, twice its length; their sculpture somewhat ill-defined; when examined from behind it seems to consist of series of moderately coarse punctures, which, when scrutinized sideways, appear as if they were transformed into granules, a peculiarity which is also apparent in some species of *Coxelus*.

Antennae sparsely pubescent, the exposed part of the 1st joint not longer than the 2nd, 3rd twice as long as broad, 4th slightly longer than 5th, 8th small and transverse. Club oblong, abruptly enlarged, unsymmetrical, being attached to the 8th joint outside the middle, its basal joint almost as broad as the intermediate, the terminal large and rotundate.

It may be distinguished from the other recorded species by the flattened sides of the thorax and peculiar sculpture. The setae on the tibiae are rather fine.

Length, 6 mm.; breadth, 3¼ mm.

Akatarawa, near Wellington. My specimen was found by Mr. A. O'Connor.

3221. Tarphiomimus tuberculatus sp. nov. *Tarphiomimus* Wollaston, Man. N.Z. Coleopt., p. 182.

Elongate, very uneven, opaque; fuscous; antennae and tarsi piceo-rufous; sparingly clothed with inconspicuous, elongate, yellowish-grey squamae.

Head granulate, antennary orbits only moderately developed. Thorax in its widest part, near the front, about a half broader than long, very much narrowed towards the base; its sides bilobed, the anterior lobe

large, with a deep semicircular excision between it and the dentiform second one, which is situated near the middle, the prominent posterior angle can hardly be termed a lobe; disc much elevated, with a broad channel from front to rear, a pair of strongly elevated prominences form the lateral boundary of the channel in front, there is a pair of smaller ones behind, and another, less elevated but more elongate, near the middle of the base; the sculpture is granular. Elytra more than double the length of thorax, their sides nearly vertical, with serrate margins; on each elytron there is an elongate tubercle at the base, not far from the suture, a pair behind the basal one but nearer the side, on top of the declivity (posterior), near the suture, a rounded prominence, and a pair of smaller ones lower down; there are some others on the side, and a minute one behind the middle, near the suture; the disc is almost flat along the middle, with nearly seriate granular sculpture.

Antennae with fine setae, those, however, on the thick basal joint are coarser and brassy; 2nd stout, oviform; 3rd elongate, but not quite as long as the 4th and 5th combined. Legs with curled squamiform setae; tibiae flexuous.

Underside opaque, reddish; the metasternum, basal ventral segment, and middle of prosternum with distinct granules and very few yellow setae, the other segments more finely sculptured, flanks of the prosternum covered with sappy matter.

An obscurely coloured elongate species, with stouter legs than *T. indentatus*, and with altogether different sculpture, the elytral prominences being distinctly separated from one another.

Length, $4\frac{1}{3}$ mm.; breadth, $1\frac{2}{3}$ mm.

Mount Greenland, near Ross. From Mr. H. Hamilton's collection.

3222. Ulonotus uropterus sp. nov. *Ulonotus* Erichson, Man. N.Z. Coleopt., p. 186.

Elongate, transversely convex, subopaque; fusco-piceous, thoracic lobes and legs pale fusco-rufous; the sides of the body bear short dark setae, the elevated parts slender yellow ones, the legs coarse greyish ones.

Head subquadrate, with close granular sculpture. Eyes free, prominent. Antennae sparsely pubescent, the club more densely; 2nd joint nearly as long as the exposed part of the 1st, not quite as stout; 3rd distinctly longer than 4th or 5th; joints 6–8 shorter, and moniliform; club oblong-oval, its intermediate joint larger than 9th, but shorter than the 11th. Thorax bilobed, the frontal lobe large, its apex attaining the eye, the 2nd is quite dentiform and placed at the middle of the side, posterior angles rectangular; its middle portion—*id est*, without the lobes—is longer than broad, binodose in front and projecting somewhat over the head, it is without other inequalities and is distinctly granulate. Scutellum small. Elytra with slightly rounded shoulders, yet quite as broad as thorax at the base, quite twice its length, with thick distinctly prolonged apices, the lateral margins only indistinctly serrate; they are closely seriate-granulate; 3rd interstices a little elevated at the base; just at the summit of the posterior declivity on each elytron there is a pair of prominent nodosities; in line with the outer, but a little further in advance of it, there is a less-prominent one.

The tail-like prolongation of the elytral apices will at once lead to its recognition.

Length, $3\frac{1}{2}$ mm.; breadth, $1\frac{1}{4}$ mm.

Wairiri, Kaikoura. Unique. Found under bark by Mr. W. L. Wallace.

3223. **Ulonotus wallacei** sp. nov.

Oblong, elongate, transversely convex, opaque; fuscous, variegated with yellowish-grey, obscure rufous, and black; the thoracic lobes, legs, and antennae fusco-rufous, the middle of the tibiae often fuscous.

Head narrowed anteriorly, with rather coarse brassy setae and granular sculpture, the antennal prominences distinct. Thorax a third broader than long, its frontal lobe largest and extending to beyond the eye; the 2nd, just behind the middle, is much smaller, deeply and rather widely separated from the 1st; 3rd barely half the size of 2nd, and nearly forming the basal angle; disc uneven, with a large angular depression on the middle, a much smaller one at the base, the other, at the apex, is not always distinctly angulate; the setae are very irregularly distributed, greyish-yellow, some are squamiform, others finer. Elytra oblong, parallel, and as broad as the widest part of thorax; the series of nodules nearest each side of the suture form almost continuous ridges; their basal part is most elevated, so that the scutellar region seems depressed; the suture is much more finely nodose, and the series nearest the sides are more or less rufescent; the setae are greyish, some are coarser than others, and those on the sides, like those of the legs, are more or less erect.

Antennae with rather dark slender setae; 2nd joint thick and usually as long as the exposed portion of the 1st, these often bear coarse yellowish setae; 3rd slender, and evidently longer than the contiguous ones; joints 4–8 decrease in length; club large, dark, its basal joint about as broad as the other two. Basal three joints of the tarsi, together, rather shorter than the terminal one.

Underside nigrescent, opaque, with numerous distinct pale brassy setae; it is closely granulate; the 5th ventral segment, however, is much less so; metasternum, behind, grooved half-way along the middle.

Its nearest ally is 1708 (*U. rufescens*), which may be distinguished by the very short transverse basal joints of the club, less-convex eyes, and different coloration.

Length, 5–5½ mm.; breadth, 2–2⅓ mm.

Wairiri, Seaward Kaikouras. Several specimens found under bark by Mr. W. L. Wallace, whose name has been given to the species.

3224. **Notoulus demissus** sp. nov. *Notoulus* Broun, Man. N.Z. Coleopt., p. 183 (*Ablabus*).

Oblong, convex, subopaque; obscure fusco-rufous, the depressed scutellar region and a large median spot across each elytron dark fuscous; legs ferruginous, antennae and tarsi somewhat fulvescent, thoracic lobes testaceous; sparingly clothed with short, slender, more or less curled flavescent setae.

Head large, nearly as broad as the thoracic disc, with indistinct granular sculpture. Thorax about as broad as long, excluding the lateral lobes; uneven, with a large median impression which seems to extend to the sides, distinctly and irregularly granulate; its sides broadly explanate and bilobed; the frontal lobe is large, with its anterior angle projecting almost as far as, yet distant from, the centre of the eye, the 2nd is cylindrical and situated between the former and the base, posterior angles indistinct. Elytra twice the length of the thorax, with obtuse shoulders, so that, at the base, they are no wider than the thorax; their sides are studded with granules, and appear subserrate;

they are seriate-punctate, regularly near the suture, not so beyond; the scutellar region is depressed; there is a distinct, though not large, basal elevation of the 3rd interstices, and on the summit of the apical declivity on each elytron there is a pair of small nodosities.

Antennae with the club densely pubescent, broad and biarticulate; basal joint but little exposed above; 2nd thick, as long as broad; 3rd slender, not elongate, yet longer than it is broad; 4th and 5th slightly longer than broad; joints 6–8 moniliform and small; 9th rather broader than its predecessor, not dull and pubescent, and only about a third of the width of the club.

Only a single species, *N. brevis* (1353), resembles this, which, however, is even smaller, with more-convex elytra, rounded shoulders, and different thoracic impressions and lobes.

Length, nearly 2 mm.; breadth, 1 mm.

Mount Pirongia. December, 1909. Unique.

In its natural condition it is covered with greyish sappy matter, so that its real sculpture and thoracic lobes cannot be seen. The removal of that substance by degrees with the point of a needle and brushing with benzene is a very delicate and tedious operation in the case of a somewhat asperate insect about the size of a pin's head. At any rate, the cleaning without damage and the subsequent description of this solitary specimen occupied a whole day.

Dr. Sharp's *Bitoma sellata* (1927) should be placed in this genus. It is not in the least like the European *Bitoma*, and may be readily separated from *Ulonotus* by its biarticulate club.

3225. **Bitoma maura** sp. nov. *Bitoma* Herbst, Man. N.Z. Coleopt., p. 192.

Elongate, subdepressed, entirely dull black, with a few elongate, scale-like, yellowish setae.

Head rather smaller than thorax, with granular sculpture. Eyes of moderate size. Antennae inserted below the edge of the forehead; the exposed portion of the basal joint not longer than the thick 2nd, which is narrowed towards its base; 3rd slender, longer than adjoining ones; 4th and 5th about equal, longer than broad; 8th and 9th moniliform; the 10th obconical, twice as broad as the 9th, about as long as broad; 11th oblong, as broad as the 10th; these two joints are densely and finely pubescent, and form the club. Thorax not lobate, widest near the front, gradually narrowed backwards, with obtuse angles; the surface a little uneven, with a large depression on the middle of the disc; its sculpture is ill-defined, but appears to be granular; it is slightly broader than long. Elytra almost thrice the length of thorax, evidently broader, their sides parallel; they are broadly impressed before the middle and behind the scutellum, their sculpture seems to consist of closely placed series of granules.

So far as superficial appearance is concerned, this species stands alone. The club is unusually elongate.

Our *B. insularis* and *B. vicina* (343 and 344), so far as can be judged without dissection, will probably remain in this genus. All the other species are certainly different from the type of the genus, the European *B. crenata*.

Length, 2½ mm.; breadth, nearly 1 mm.

Waimarino; elevation, 2,600 ft.; January, 1910. One only could be found.

Group Pycnomeridae.

3226. Pycnomerus reversus sp. nov. *Pycnomerus* Erichson, Man. N.Z. Coleopt., p. 208.

Glabrous, slightly nitid, nigrescent, legs and antennae rufous.

Head subquadrate, evidently narrower than thorax, moderately finely and rather distantly punctate, very deeply bi-impressed throughout. Thorax longer than broad, its sides nearly straight, just perceptibly or hardly at all narrowed anteriorly; the apex with a slight median emargination, its angles not prominent; base somewhat curved, so that the angles are not sharply rectangular; it is distinctly but not coarsely and rather distantly punctured, moderately bi-impressed along the middle, and with the interval between the impressions rather broad and nearly smooth. Scutellum obsolete. Elytra double the length of the thorax, somewhat oviform, widest near the middle; the base slightly incurved, with incrassate angles, which therefore appear to project slightly outwardly as well as frontally; the dorsal sculpture on each elytron consists of 4 series of unequal, mostly elongate, punctiform impressions; these are connected by feeble striae, but towards the apex the stria are deep, the sutural particularly so, and also rather broad, so that the adjoining interstice appears costiform; the suture is broad and slightly expanded outwardly at the base, the 2nd and 4th interstices do not reach the base; the sculpture near the sides is finer and more punctate-striate; all the interstices and the suture have distant, minute, serial punctures.

Underside nitid, the sternum coarsely, the abdomen more finely and remotely punctured, its terminal segment with a large fovea at each side.

Belongs to section I in my cabinet, which comprises species with minute eyes and indistinct 11th antennal joints. Most nearly related to 1944, 1949, and 1950, but, independently of other details, differentiated by the finer punctation of the thorax and unusual elytral sculpture.

Length, $3\frac{1}{4}$–$3\frac{1}{2}$ mm.; breadth, 1–$1\frac{1}{4}$ mm.

Greymouth. Three examples from Mr. J. H. Lewis.

3227. Pycnomerus candidus sp. nov.

Nitid, castaneo-rufous, antennae rufous, apex of thorax fringed with fine yellowish pubescence.

Head subquadrate, narrower than thorax, frontal fovae deep; its punctation distinct but not close. Thorax of about equal length and breadth, very slightly narrowed in front, very gradually so behind, with well-developed lateral margins; apex medially truncate, but with a short sinuosity near each side, thus permitting the small eyes to be easily seen, its angles acutely prominent; posterior angles rectangular, but not extending to the base itself, close to each there is a deep transverse fossa which has a thick hind margin; it is moderately coarsely and rather distantly punctured; the dorsal impressions are well marked and elongate, and are separated by a nearly smooth space which is broader behind than in front, but not cariniform there. Scutellum small. Elytra oviform, twice the length of thorax, widest near the hind thighs, a good deal contracted posteriorly; at the base they are singly rounded, yet only gently, towards the suture, the humeral angles project forwards; they are deeply striate, with rather distant and not very definite punctures; the interstices have remote, minute serial punctures; on each elytron the

suture and adjoining interstice, as well as the cariniform 4th and 6th, do not quite reach the basal margin. Antennae with the 11th joint indistinct.

Underside rufescent, shining, with rather coarse punctures, each with a minute seta; 5th ventral segment slightly concave, and almost as coarsely punctate as the others.

A careful scrutiny of the base of the elytra will be an aid in discrimination. The anterior angles of the thorax are more acute than those of 1949, the lateral margins are thicker throughout, and the discoidal impressions are not at all sharply bordered.

Length, $3\frac{1}{2}$ mm.; breadth, $1\frac{1}{4}$ mm.

Greymouth. Unique. Found by Mr. J. H. Lewis.

Obs. — From the same source specimens were received of Sharp's *P. longulus*. If I am right as regards identification, the following notes will be useful to other students: Prosternum opaque and closely punctate; metasternum glossy, more coarsely but rather distantly punctured, medially sulcate behind; terminal ventral segment depressed or slightly concave, its frontal margin incurved, thus leaving a transverse depression at the apex of the penultimate. Size, nearly 4 mm. by $1\frac{1}{5}$ mm.

Group Bothrideridae.

3228. **Bothrideres diversus** sp. nov. *Bothrideres* Erichson, Man. N.Z. Coleopt., p. 207.

Elongate, almost glabrous, slightly nitid; black, legs and antennae rufescent.

Head moderately finely, yet distinctly, but not very closely punctate. Eyes very prominent. Thorax of about equal length and breadth, apex subtruncate, its sides nearly straight from the rectangular anterior angles to beyond the middle, slightly narrowed behind, basal angles rectangular; it is more coarsely punctured than the head, more closely near the sides than on the middle, much more finely in front; there is a slight elongate central fovea with smooth lateral borders. Scutellum sparsely punctate. Elytra with rounded shoulders, broader than thorax at the base, thrice its length, their sides gently rounded; on each elytron there are 6 dorsal finely and rather distantly punctured but not always well-defined striae; the suture, as well as the 3rd and 5th interstices, are cariniform behind; the suture is finely punctate, as are also the plane intervals between the adjacent striae.

Antennae with slender pubescence, basal 2 joints normal, both thick; 3rd evidently longer than broad; joints 4–8 about equal, as long as they are broad; 9th rather longer than its predecessor; 10th quite as long as broad, narrowed towards its base, at its apex not double the width of the 9th; 11th rotundate, rather narrower than the 10th.

The club is usually composed of the abruptly enlarged transversal 10th and 11th joints, whereas in this species the 10th is subtriangular and, at its base, no broader than the extremity of the 9th, and the 11th, though rounded, is as long as broad.

The insect is rather more slender than previously recorded species, and has more convex and prominent eyes. The few ash-coloured slender setae are hardly perceptible.

Length, $3\frac{1}{2}$ mm.; breadth, $1\frac{1}{4}$ mm.

Wairiri, Kaikoura. One individual, along with a specimen of *B. moestus* (367).

Group Cryptophagidae.

3229. Cryptophagus amoenus sp. nov. *Cryptophagus* Herbst, Man. N.Z. Coleopt., p. 224.

Minute, elongate-oblong, moderately transversely convex, nitid; castaneo-rufous, legs and terminal joint of antennae fulvescent, remainder of these latter rufous; sparingly clothed with suberect pale flavescent setae.

Head evidently narrower than thorax, not trigonal, the forehead subtruncate, it is smooth on the middle, moderately coarsely, proportionally, punctured at the sides, and with a series of coarse punctures across the occiput. Eyes convex, with distinct facets. Antennae inserted in front of and just below the margin of the forehead, 11-articulate; basal joint stout; 3rd rather longer than 2nd; 4th and 5th as long as broad and about equal, rather shorter than their predecessor; joints 6–8 rather smaller and moniliform; 9th rather narrower than 10th, but larger than 8th; 10th transverse; 11th conical. Thorax subquadrate, slightly and very gradually narrowed towards the obtuse front angles, its sides marginate but nowhere denticulate; base slightly bisinuate, with nearly rectangular angles, its length and breadth about equal; the surface, relatively, moderately coarsely punctate. Scutellum transverse, smooth. Elytra as broad as thorax at the base, almost twice its length, slightly narrowed posteriorly; with fine sutural striae, their punctation a little finer and more distant than that of the thorax, and becoming finer and less distinct behind.

Tibiae somewhat dilated towards the extremity, unarmed. Tarsi quadriarticulate, the basal three joints of about equal length, each of these furnished with a slender elongate seta, the terminal rather longer than the others taken together, with distinct claws.

A single specimen only of this minute insect has been secured. It is not a true *Cryptophagus*, neither does it agree with any of our *Cucujidae*, to which group nevertheless it will no doubt be transferred as the type of a distinct genus if other specimens can be obtained.

Length, $1\frac{1}{2}$ mm.; breadth, $\frac{1}{2}$ mm.

Makatote. Found amongst leaf-mould collected for me in February, 1910, by Mr. W. J. Guinness.

Group Lathridiidae.

3230. Corticaria fuscicollis sp. nov. *Corticaria* Marsham, Man. N.Z. Coleopt., p. 234.

Variegate, head and thorax piceo-fuscous, elytra rufo-castaneous, more flavescent near the shoulders and apex, legs and antennae infuscate, the knees and basal joints of the tarsi paler; pubescence yellowish, scanty, and suberect, most conspicuous near the shoulders and on the posterior declivity; slightly nitid.

Head nearly as broad as the widest part of thorax, moderately coarsely but not closely punctate. Eyes prominent, occupying almost the whole side of the head from the point of antennal insertion. Antennae as long as head and thorax, with a few fine dark setae; basal joint subpyriform; 2nd not as stout, oviform; joints 3–8 slender, all longer than broad; club loosely articulated, the terminal joint largest, ovate. Thorax a little broader than long, rather wider near the front than elsewhere, its sides moderately rounded; there is a shallow impression near the front and

another near the base, close to the basal margin there is a transverse linear depression, its punctation is irregular and rather coarse. Scutellum small. Elytra oblong, much broader than thorax, the shoulders rounded but not at all elevated, sutural striae distinct, their relatively coarse punctures are nearly quite seriate, but become finer behind.

Legs pubescent; anterior tibiae slightly bent near the extremity; tarsi slender, terminal joint quite as long as the basal two united.

Our nearest species, *C. terricola* (2784), has a rather shorter, subovate hind-body, with distinctly raised shoulders.

Length, 1½ mm.; breadth, ⅔ mm.

Erua. January, 1910. One, found amongst dead leaves.

Group Byrrhidae.

3231. **Pedilophorus opaculus** sp. nov. *Pedilophorus* Steffahny, Man. N.Z. Coleopt., p. 244 = *Morychus.*

Oval, moderately convex, glabrous, subopaque, head and thorax slightly shining; nigrescent, the legs and basal joints of antennae piceo-rufous, the terminal six joints infuscate.

Head distinctly and moderately closely punctured, the labrum rather more coarsely. Thorax more than twice as broad as it is long, the sides gradually narrowed anteriorly, with their margins slightly thickened near the base, the apex finely margined behind the eyes, posterior angles rather more acute than the anterior; its punctation is just a little finer than that of the head. Scutellum triangular. Elytra of the same width as thorax at the base, somewhat broader near the middle, a good deal narrowed behind, their margins very distinct at the shoulders; along the middle of the disc the punctures are evidently finer than those on the thorax, they become even finer towards the sides, and on the hind slope the sculpture is finely coriaceous; on each elytron, near the suture, 3 irregular series of coarser punctures extend to beyond the middle, and between these and the side 4 or 5 irregular indefinite striae may be seen; none of these reach the base, which is more finely sculptured than the dorsum.

Antennae elongate, joints 6–11 broader than the preceding four and distinctly pubescent, the 4th joint as long as the 5th. Tibiae very scantily and finely setose, the anterior grooved along their outer face, the intermediate less strongly curved externally than those of *P. lewisi* (2794), and tapering more towards the extremity. The membranous appendage of the 3rd tarsal joint is prolonged under the 4th.

Underside slightly nitid, black, with very scanty, fine, ashy pubescence. Metasternum moderately coarsely punctured; the prosternal process rather broad, and, like the mesosternum, finely punctate. Trochanteral portion of the posterior coxal laminae rather longer than in 2794. Abdomen finely punctured, the 5th segment slightly convex and nearly smooth in the middle, with a feeble transverse impression behind.

The dull elytra, with only very faintly viridescent sides, and cessation of perceptible punctures towards the posterior portion, will enable entomologists to separate this species from 2794, which is altogether more glossy and aeneous, rather smaller, with the 4th antennal joint shorter than those next to it. The underside also differs, the 5th ventral segment being shorter, with distinct yellow hairs and an apical fovea. In Pascoe's description of *Liochoria huttoni* there is no allusion to serial

punctures or striae on the elytra; it must therefore be distinct from this species and *P. lewisi*.

Length, 8–9 mm.; breadth, 5 mm.

Bold Peak, Wakatipu. Another of Mr. H. Hamilton's discoveries.

Group Copridae.

3232. **Saphobius lepidus** sp. nov. *Saphobius* Sharp, Man. N.Z. Coleopt., p. 255.

Subquadrate, moderately nitid, bearing short, rather fine, flavescent setae, which on the elytral interstices are disposed in almost regular duplicate series; nigrescent or rufo-piceous, legs dark rufous, antennae and palpi rufo-testaceous.

Head narrowed towards the front, bidentate there, rather coarsely and closely punctured. Thorax twice as broad as long in the middle, widely emarginate and with acute angles in front, the sides nearly straight for two-thirds of their length, then obliquely narrowed anteriorly, the base slightly rounded, its angles, nevertheless, nearly rectangular; with shallow oviform impressions rather than punctures, these are not very close, and each has a short seta proceeding from it, there is only a slight longitudinal depression behind. Elytra of exactly the same width as the thorax at the base, broadly rounded posteriorly, and covering the pygidium; on each there are 6 lines, which can hardly be termed striae.

Tibiae finely setose, the anterior curvate, gradually dilated, obliquely truncate at the extremity and with acutely prominent external angles, there are 2 more denticles on the outer edge. Intermediate and hind tarsi well developed, the anterior slender and abbreviated, so that during repose they do not extend outwards as far as the external angle of the tibae.

Antennae inserted below the sides of the head; their elongate basal joint, which is as long as the following five combined, is therefore partly concealed from above; 2nd conical, stouter than the 1st; 3rd and 4th small; 5th and 6th somewhat transversal; club moderate, pubescent, triarticulate.

Underside shining, piceous, with minute setae, the sternum coarsely punctate, abdomen finely, metasternum nearly smooth on the middle.

In other species the eyes, though not at all prominent, are quite discernible above; they extend downwards, and are situated at the back part of the head just inside the thoracic angles, but in this species they are almost invisible above, though well developed underneath; these organs, therefore, and the neatly arranged setae on the elytra, will enable this species to be identified.

Length, head exserted, 4 mm.; breadth, 2½ mm.

Erua, near Waimarino. Found amongst decaying leaves on the ground (elevation, 2,500 ft.), January, 1910; and sent during March by Captain H. S. Whitehorn, of the Geological Survey Department, amongst vegetable matter collected at the head of the Retaruke River, about five miles from Erua.

Group Melolonthidae.

3233. **Odontria nitidula** sp. nov. *Odontria* White, Man. N.Z. Coleopt., p. 265.

Convex, subovate, shining; testaceous; the vertex, middle of thorax, and tibial teeth more or less infuscate; forehead rufo-castaneous, spar-

ingly clothed with decumbent, pale yellow, and outstanding elongate hairs, these latter chiefly confined to the sides.

Head coarsely punctured, the forehead rather less so, with dark reflexed margins, which are obtusely rounded in front. Thorax only half as long as broad, apex widely emarginate; base distinctly margined, rather deeply bisinuate, so as to appear somewhat lobate, or obtusely prominent, in the middle, its angles obtuse, the sides gently curvedly narrowed towards the front; it is very distinctly punctate, but not as coarsely as the head, and is slightly impressed along the middle. Elytra nearly thrice the length of thorax, of the same width as it is at the base, much broader behind, apices subtruncate; the sutural striae moderately impressed, the others more or less indefinite, quite obsolete near the base, their punctation irregular, similar to that of the thorax.

Antennae short; 2nd joint nearly as stout as the 1st, but shorter; 3rd and 4th of about equal length; 5th very short, simple; club triarticulate. Anterior tibiae tridendate.

The somewhat glossy surface, pale colour, very distinct thoracic punctation, and the rather lobate base distinguish this from all the other species except White's *Rhizotrogus zealandicus* (474). In one example the elytra are slightly infuscate.

♀. Length, 12–14 mm.; breadth, 7–8 mm.

Titahi Bay, Wellington. One from Mr. A. O'Connor.

3234. **Odontria monticola** sp. nov.

Oblong, a little dilated posteriorly, opaque; light yellowish-brown, and, excepting the head, almost immaculate; the decumbent pubescence rather slender, pale greyish-yellow, the erect setae much more elongate and more scanty; head fusco-testaceous, the middle irregularly dark fuscous, as are also the outer edges of the anterior tibiae and all the tarsi.

Head very sparingly and coarsely punctured, the reflexed margins of the clypeus gradually narrowed anteriorly and subtruncate at apex. Thorax with the breadth double the length, incurved in front, bisinuate at the base, posterior angles obtusely rectangular, its surface finely and rather distantly punctured. Elytra thrice the length of thorax, with slender striae, which are moderately definite behind but less so near the base; the seriate punctures are blackish, distinct, regular, and small, and are separated by intervals of about the same size as themselves; interstices plane, finely but not closely punctate; apices subtruncate; pygidium short, fuscous.

Male.—Antennae short, their 1st joint stout, 2nd shorter, both dilated towards the extremity; 3rd elongate; the 4th nearly as much elongated as the 5th, which is just as long as the other leaflets; the club, consequently, is 5-articulate.

Female.—Antennae short, their 5th joint very short and hardly at all produced; the club is therefore composed of three leaflets. Thorax more sparingly pubescent, so that the fine, though not close, punctation can be easily seen. Elytra with less nigrescent, less regular, but slightly coarser punctures, and therefore with less discernible linear sculpture than in the male, and with a few light-fuscous spots on some of the interstices.

The stature is about the same as that of *O. striata*, but in it the dark lines and serial punctures on the elytra are distinct in both sexes, and the interstices have numerous large obvious dark spots.

Length, 16 mm.; breadth, 9 mm.

Bold Peak, Wakatipu. A pair, mounted on cardboard, forwarded for inspection by Mr. A. O'Connor, of Wellington. The male was captured by Mr. Howie, the female by Mr. H. Hamilton.

3235. **Odontria similis** sp. nov.

Oblong, elongate, slightly convex, opaque; thinly covered with depressed, yellowish-grey, moderately short and slender hairs, and with coarser, elongate, and somewhat rufescent ones along the sides and on the head; the base of thorax also with elongate but much paler ones; legs fusco-testaceous.

Head coarsely and very irregularly punctured, the back part and a large spot near each eye almost smooth, its rims reflexed and very slightly curved in front. Thorax of the usual form, twice as broad as long, moderately finely and not closely punctate. Scutellum sparingly punctured. Elytra slightly widened behind, apices very slightly rounded; they are of the same width at the base as the thorax, but fully thrice its length; the sutural striae are distinct and finely punctate, the others are shallow and indefinite, the interstital punctation is fine. Pygidium broadly obconical, medially angulate at the extremity, with shallow rugose sculpture.

Similar in form to *O. marmorata*, the thorax and hind-body light brown, but both very irregularly and numerously maculate with dark fuscous, so that the insect appears much darker; the pygidium is pitchy brown instead of being somewhat testaceous; the head is dark shining brown, with a testaceous streak across it near the back. The breast is testaceous, finely and rather distantly punctate and pubescent; the abdomen is fuscous and more closely punctured. The labrum is more vertical and less prominent. The 5th antennal joint, though short, is rather more produced; the club is triarticulate. *O. fusca* (2518) has striate elytra.

Length, 14 mm.; breadth, 8 mm.

Mount Greenland, near Ross; elevation, 2,500 ft. Found by Mr. Hamilton.

3236. **Costleya simmondsi** sp. nov. *Costleya* Broun, Man. N.Z. Coleopt., p. 1115.

Broadly oval, moderately convex, nitid; nearly glabrous, having only a few slender setae on the head and along the sides, the pygidium and tibiae with coarser ones; the clypeus, elytra, and sides of thorax fusco-testaceous tinged with green; the back of the head and middle of thorax light fuscous; tibiae piceous, more or less viridescent, the outer edge of the anterior reddish; antennae pale castaneous, club opaque and nearly black.

Head irregularly, coarsely, but not closely punctured; clypeus with somewhat reflexed margins, slightly medially incurved in front. Thorax nearly twice as broad as it is long, its sides finely rimmed, more narrowed in front than behind, its base strongly bisinuate, the apex deeply emarginate, front angles projecting beyond the middle of the eyes; its punctation coarse, not very close, but irregular; there is a median impression near the front. Elytra of the same width as thorax at the base, rather wider behind the middle, apices obtusely rounded towards the suture; with rather broad, closely punctured striae; interstices smooth, the 3rd, 5th, and 7th broader and more elevated than the others, their sculpture, however, becomes indistinct near the apices; the lateral margins are somewhat explanate almost to the extremity.

Antennae 8-articulate, basal joint largest, dilated towards the extremity, 2nd rather longer than 3rd and twice as stout, 4th longer than the preceding, gradually thickened, 5th very short but not broader than the 4th; club composed of 3 rather short equal leaflets.

Differs from 1977 (*C. discoidea*) in coloration, by the coarse sculpture of the head and thorax, deep elytral striae and more costiform interstices, obviously tridentate anterior tibiae, and by the more elongated tarsal joints.

Length, 14 mm.; breadth, 8 mm.

Mount Alpha, near Wellington; elevation, about 4,500 ft. Described from a specimen mounted on cardboard and sent for examination by Mr. Hubert Simmonds, of Wellington, in whose honour it has been named.

Group Eucnemidae.

3237. **Talerax dorsalis** sp. nov. *Talerax* Sharp, Man. N.Z. Coleopt., p. 279.

Subparallel, moderately narrow, nitid; black; legs fuscous; the knees, tarsi, and apical margin of thorax castaneous; pubescence cinereous, slender, and elongate, slightly flavescent and thicker at the base of the thorax.

Head almost as broad as the front of the thorax, feebly medially impressed, distinctly but not very closely punctate. Eyes large and prominent. Thorax a third broader than long, apical margin somewhat reflexed and broadly rounded, posterior angles robust, rather long, a little curved, not at all divergent; disc convex, distinctly yet rather finely but nowhere closely punctured. Scutellum minutely sculptured. Elytra as broad as thorax at the base, thrice its length, tapering very gently towards the extremity; the shoulders and each side of the suture, at the base, obtusely elevated, sutural striae indefinite but terminating near the apices in deep foveiform depressions, their punctation is coarser than that of the thorax and appears slightly rugose in some aspects, there are also some obsolete striae near the middle.

Legs very finely pubescent; tarsi slender, simple, basal joint nearly as long as all the following ones, their penultimate joint with slender lobes. Antennae distinctly but not widely separated at the base; 1st joint stout and somewhat curved; 2nd very short and feebly rufescent; 3rd elongate, as long as the 1st; joints 4–10 subserrate, all longer than broad, the 4th, however, is shorter than adjoining ones; 11th elongate; they bear distinct infuscate pubescence.

T. micans (2366) comes nearest, but is rather larger, its thorax is more glossy and irregularly punctured, so that the middle and other spots are almost smooth, the elytral sculpture is more definite, the basal elevations less so.

Length, $3\frac{2}{3}$ mm.; breadth, $1\frac{1}{3}$ mm.

Mount Pirongia. One captured by myself in December, 1909.

Group Elateridae.

3238. **Protelater diversus** sp. nov. *Protelater* Sharp, Man. N.Z. Coleopt., p. 304.

Narrow, elongate, and shining, pitchy black, elytral base somewhat rufescent, the knees and claws pale castaneous; pubescence scanty, slender but distinct, greyish-yellow.

Head rather large, finely and irregularly punctate, with a pair of nearly smooth spots on the vertex. Eyes prominent. Antennae filiform, densely and finely pubescent, their 9th joint reaching backwards to the shoulder; 3rd joint slightly shorter than 2nd, these, together, about as long as the 4th. Thorax elongate, its length more than doubt the breadth at the middle, with rather thick and very divergent posterior angles, the anterior rectangular and with a pale transverse spot near each; its whole surface very distinctly and moderately closely punctured. Elytra elongate, tapering gradually towards the rounded apex; they are rather closely and coarsely punctate-striate, but less distinctly punctate near the base; interstices finely punctured, the 3rd and 5th more elevated behind than the others.

Underside nigrescent, moderately punctate, with greyish pubescence.

The species most resembling this, 1369 (*P. nigricans*) and 1990 (*P. urquharti*), may be readily separated, the former by the less divergent and rufescent thoracic angles and shorter, stouter antennae; the latter by the very fine thoracic sculpture, and by the striae being nearly obsolete on the basal half of the elytra.

♂. Length, 10 mm.; greatest breadth, $2\frac{1}{2}$ mm.

Mount Quoin. Found on dead trunks of *Fagus*, at an elevation of about 3,800 ft., by Mr. H. Simmonds, from whom a specimen has been received.

3239. **Chrosis dubitans** sp. nov. *Chrosis* Sharp, Man. N.Z. Coleopt., p. 296.

Robust, not parallel; pubescence distinct, pale brassy; nitid, rufopiceous, antennae nigrescent.

Head moderately coarsely and irregularly punctured, with a nearly smooth space near each eye. Antennae finely pubescent, hardly attaining the base of thorax, 3rd joint rather longer than 2nd. Thorax of about equal length and breadth, gradually narrowed anteriorly, with carinate, robust, and slightly divergent basal angles; the sides, before the middle, are broadly yet slightly impressed, there is an elongate median impression near the base, and near the front an indistinctly elevated line, the disc is finely and rather distinctly punctured, but the sculpture becomes closer and more distinct near the sides and apex. Elytra rather deeply striate, the outer striae evidently punctate; interstices distinctly but not very closely punctured, the 2nd becomes obsolete behind the middle; apices rounded singly.

Nearly allied to *C. barbata* (529), and perhaps only one of several varieties. It is distinguished by the rather distant sculpture of the thorax and the abbreviation of the 2nd elytral interstices.

Length, 16 mm.; breadth, 5 mm.

Mount Alpha, near Wellington. Found under stones, at an altitude of 4,700 ft., by Mr. H. W. Simmonds.

3240. **Corymbites fulvescens** sp. nov. *Corymbites* Latreille, Man. N.Z. Coleopt., p. 299.

Elongate, subparallel, nitid; fulvescent, the head, thorax, and basal five joints of the antennae reddish, legs testaceous, tibiae lighter than the tarsi; elytra densely clothed with slender yellowish hairs, the thorax more sparingly.

Head densely punctured and distinctly pubescent. Thorax, in the middle, scarcely longer than broad, somewhat curvedly narrowed near

the front, subparallel behind; its basal angles finely carinate above and directed backwards, the anterior prominent but obtuse; the surface moderately closely and rather finely punctate, still more finely near the base; there is no median impression. Elytra thrice the length of the thorax, a little wider near the hind thighs than at the shoulders, their apices emarginate and minutely angulate; they are finely punctate-striate, with minutely sculptured interstices.

Underside fulvescent, very finely clothed and punctured, the sternal structure similar to that of *C. antipodum*.

Antennae filiform, attaining the base of the thorax, their 2nd joint quite half the length of 3rd.

It may be readily identified by being more brightly coloured than any New Zealand member of the genus. *C. antipodum* (532) is its nearest ally, but the punctate elytral striae and the differently formed and less densely sculptured thorax are distinctive.

Length, 14 mm.; breadth, 4 mm.

Wairiri, Seaward Kaikouras. A single individual found by Mr. W. L. Wallace, of Timaru.

3241. Corymbites vitticollis sp. nov.

Elongate, slightly nitid, fuscous; the elytra with a broad streak along the middle of each, and the suture somewhat rufescent; the thorax with a more definite and rather broad reddish median streak, its sides paler; legs and antennae testaceous; the clothing flavescent, rather dense, and coarser on the head and labrum than it is on the elytra.

Thorax moderately convex, about a fifth longer than broad, in the middle, posterior angles indistinctly carinate and almost quite straight, its surface closely and moderately finely punctate. Elytra rather finely sulcate, the sutural pair of striae impunctate, the punctation of the others becoming coarser towards the sides, interstices closely and very finely punctured, the apices simple.

Underside pale castaneous, but with the flanks of the prosternum testaceous and very distinctly punctured, metasternum medially sulcate, abdomen finely and closely punctate; with fine greyish-yellow pubescence.

Antennae short, not attaining the base of thorax, their 2nd joint only a little shorter than the 3rd, which is rather shorter than the 4th. Tarsi elongate, their penultimate joint but little more than half the length of the 3rd.

Distinguishable from *C. strangulatus* by its coloration, simple and less divergent thoracic posterior angles, differently formed antennae, &c.

Length, 13 mm.; breadth, 3½ mm.

Silverstream, near Wellington. A pair of mounted specimens received from Mr. A. O'Connor.

3242. Corymbites approximans sp. nov.

Elongate, a little shining, castaneo-rufous, the legs and basal two joints of antennae testaceous, remaining joints infuscate; pubescence yellowish-grey.

Thorax closely and moderately finely punctate in the middle, about a fifth longer than broad, with slightly divergent and finely carinate posterior angles. Elytra with narrow impuncate striae, interstices closely and finely punctured, apices simple.

Underside rufo-fuscous, densely and finely punctate and pubescent, metasternum medially sulcate.

Antennae filiform and elongate, reaching backwards just beyond the middle femora, 2nd joint more than half the length of 3rd, the latter as long as the 4th.

In some respects like *C. antipodum* (532), but differing from it in colour, &c. It is easily separable from *C. vitticollis* by the impunctate elytral striae.

♂. Length, 13 mm.; breadth, 3 mm.

Silverstream. Also discovered by Mr. O'Connor.

3243. Corymbites sternalis sp. nov.

Elongate, rather slender, slightly nitid; elytra fusco-rufous, the thorax of a lighter hue, with its sides and base subtestaceous, the legs, palpi, and basal two joints of antennae testaceous, the other joints fuscous; rather closely covered with slender yellowish hairs.

Head very distinctly and closely punctured. Thorax slightly longer than broad, basal angles very slightly divergent, not perceptibly carinate; the surface closely and moderately finely punctate. Elytra with simple apices, the striae nearest the suture rather fine and impunctate, the outer ones distinctly yet rather finely punctured, the punctation of the interstices very fine and close.

Antennae elongate, extending as far as the intermediate thighs, their 2nd joint fully half the length of the 3rd, which equals the 4th. Tarsi elongate, their penultimate joint well developed.

Underside fusco-rufous, closely and very finely punctate, with slender greyish pubescence; flanks of prosternum testaceous, densely and rather finely punctured, saltatorial process fuscous.

Rather smaller than 532, much more brightly coloured, its thorax differently shaped, not at all straight-sided.

Length, 10 mm.; breadth, 2½ mm.

Silverstream. The third species of this genus obtained by Mr. O'Connor within a limited area, and, so far as I know, not occurring elsewhere.

Group Dascyllidae.

3244. Atopida basalis sp. nov. *Atopida* White. Man. N.Z. Coleopt., pp. 311 and 1141.

Elongate, slightly nitid; head and thorax fusco-rufous, elytra castaneous with suffused dark marks, legs and palpi testaceous; antennae infuscate from the 4th joint onwards, 2nd and 3rd yellowish, the basal joint rufescent; clothed with decumbent yellowish hairs, those on the elytra coarser and greyish.

Head large, including the slightly convex eyes, as broad as the front of thorax, closely and rather finely punctate-granulose. Thorax nearly twice as broad as long, base and apex subtruncate, with acutely rectangular angles, the anterior somewhat depressed, its sides sinuously narrowed behind, in one example strongly rounded at the middle; the sculpture dense, less close at the basal margin, not coarse, punctate-granulose. Scutellum triangular, elongate. Elytra evidently broader than thorax at the base and about four times its length, subparallel, slightly transversely impressed before the middle, irregularly but not coarsely punctured, with a tendency to become subgranulose near the shoulders.

Antennae reaching backwards to beyond the base of the elytra, their 1st joint stout, 2nd short and moniliform, 4th thicker than 3rd and quite as long.

In *A. sinuata* (2524) a basal sinuosity near each side of the thorax causes the posterior angles to appear as if they were directed backwards; this is not the case in the present species, which, moreover, has more finely sculptured elytra, differently coloured antennae, and larger eyes.

Length, 5½ mm.; breadth, 2¼ mm.

Kaitoke, near Wellington. I am indebted to Mr. A. O'Connor for a pair of specimens.

3245. **Mesocyphon mandibularis** sp. nov. *Mesocyphon* Sharp, Man. N.Z. Coleopt., p. 316.

Robust, subdepressed, moderately nitid, unevenly clad with distinct yellowish pubescence; rufescent, the elytra with irregular fuscous and testaceous marks.

Head densely and distinctly but not coarsely punctured. Eyes prominent. Mandibles elongate, more than half of their whole length exposed. Antennae elongate, rather stout, their 3rd joint almost as long and thick as the 4th; 5–10 about equal, their length about double the breadth, each narrowed towards the base; 11th oviform; they bear fine pubescence. Thorax a third broader than long, its apex slightly bisinuate, anterior angles rectangular and only a little deflexed; its sides nearly straight and distinctly margined, with nearly rectangular basal angles; its sculpture is like that of the head, but on a spot at each side of the interrupted median impression the punctures are more distant. Scutellum large, thickly pubescent. Elytra evidently wider than thorax at the base, gradually expanded backwards; on each, alongside the suture, there is a shallow basal impression which is curved outwards and becomes broader near the middle; there is also an indefinite discoidal costa; their punctation is rather finer than that of the head.

There is no perceptible curtailment of the anterior portion of the head; the unusual exposition of the mandibles is caused by their length. It is rather larger than *M. divergens* (575), with a broader head, and impressed thorax and elytra.

Length, 7½ mm.; breadth, 3¼ mm.

Mount Alpha, Tararua Range. Several specimens found under a stone, at a height of 4,800 ft., by Mr. H. Simmonds, who presented me with a pair.

3246. **Cyphon pachymerus** sp. nov. *Cyphon* Payk, Man. N.Z. Coleopt., p. 318.

Subopaque, broadly oval, slightly convex; elytra densely clothed with inconspicuous, slender, cinereous pubescence; body smoky black, legs and basal two joints of antennae fuscous.

Head short and broad, very minutely granulate. Antennae with the 3rd joint very small, yet rather longer than broad, 4th evidently larger than the following ones. Thorax strongly transverse, its sides but little rounded, their margins much finer than the basal, with subrectangular angles, the anterior somewhat deflexed, its sculpture like that of the head. Scutellum large. Elytra ample, without depressions, closely and finely punctured.

Femora incrassate, the posterior particularly; hind tibiae with a pale, very elongate terminal calcar. These two characteristics at once differentiate this species from its allies. In general appearance *C. aethiops* (1730) most nearly resembles it.

An aberrant species, probably representing a distinct genus.

Length, nearly 3 mm.; breadth, quite 1½ mm.

Silverstream. Both of my specimens were discovered by Mr. A. O'Connor, of Wellington.

Group Melyridae.

3247. Arthracanthus foveicollis sp. nov. *Arthracanthus* Broun, Man. N.Z. Coleopt., p. 781.

Elongate, slightly nitid; pubescence greyish, slender yet quite distinct; elytra, legs, and basal four joints of antennae more or less infuscate, tibiae rather more rufescent, remaining joints of antennae piceous, head and thorax nigrescent.

Head slightly broader than thorax, with a large median fovea behind; it is finely and distantly punctate. Eyes large and prominent. Thorax of equal length and breadth, obtusely dilated laterally at the middle, distinctly but finely and rather distantly punctured, with a median linear impression in front, a basal fovea at the middle, and a shallow impression at each side. Scutellum distinct. Elytra elongate, subparallel, wider than thorax at the base; distinctly, moderately closely, and rugosely punctured.

Antennae stout, not serrate, basal two joints thick, 3–5 moderately elongate and about equal, 6–10 similarly elongate, 9th and 10th somewhat triangular, 11th elongate-oval. Legs elongate, the basal joint of the anterior tarsi with a spiniform process at its front or inner angle.

Female.—Occipital fovea absent. Basal joint of anterior tarsi very short, not distinctly spinose.

The thoracic fovea is distinctive.

Length, 2½ mm.; breadth, ⅔ mm.

Akatarawa, Wellington. Two specimens, mounted on cardboard, from Mr. A. O'Connor.

Group Cleridae.

3248. Phymatophaea griseipennis sp. nov. *Phymatophaea* Pascoe, Man. N.Z. Coleopt., p. 334.

Elongate, subdepressed, with numerous erect, slender greyish setae, subopaque; nigrescent, but the elytra, with the exception of their basal portion, are yellowish-grey; antennae and tarsi infuscate.

Head very closely and coarsely punctured. Thorax of about equal length and breadth, obtusely dilated laterally behind the middle, its punctation hardly as close and coarse as that of the head, finer in front, with a pair of smooth, slightly raised spots before the middle. Scutellum subtriangular. Elytra thrice as long as thorax, not twice its width at the base, rather wider behind, without inequalities of surface; evenly punctured, more coarsely but not quite so closely as the thorax.

Legs pilose, anterior tibiae moderately curved. Tarsi with well-developed membranous appendages, claws thickened but not dentate. Eyes prominent, finely faceted, emarginate in front.

Length, 5 mm.; breadth, 1¾ mm.

Silverstream, near Wellington. A single specimen, from Mr. A. O'Connor.

3249. **Parmius violaceus** sp. nov. *Parmius* Sharp, Man. N.Z. Coleopt. p. 331.

Elongate, subdepressed, shining; violaceous, the tibiae and basal two joints of antennae fusco-testaceous, remaining joints and the tarsi darker, the front of the forehead and the clypeus pale yellow; the body and legs with numerous outstanding conspicuous pallid hairs.

Head, including the large prominent eyes, as broad as the middle of thorax, longitudinally bi-impressed in front; it is very irregularly, finely, and indistinctly punctured. Thorax of about equal length and breadth, a good deal dilated laterally near the middle; its surface apparently impunctate but finely transversely rugose, with an angular basal impression and a pair of small shallow foveae near each side. Elytra a little uneven, with slightly elevated irregular rugae.

Antennae rather short, their basal joint stout and evidently longer than 2nd; joints 3–8 differ but little, each longer than broad; club triarticulate, its intermediate joint cordate and hardly as long as the others.

More robust than the representative species, 602. In this species, as well as 602, 603, and 2037, there is a more or less definite emargination of the eyes; the author's generic diagnosis therefore requires correction.

Length, 6½ mm.; breadth, 2 mm.

Mount Quoin. Described from a mounted specimen forwarded by Mr. Hubert W. Simmonds.

Group Anobiidae

3250. **Anobium inaequale** sp. nov. *Anobium* Fabricius, Man. N.Z Coleopt., p. 339.

Cylindric, uneven, variegate; fuscous, the base and the elevations of the elytra somewhat rufescent, legs and antennae rufo-piceous, tarsi obscure fusco-testaceous; vestiture unequally distributed, variegated, flavescent and greyish.

Head vertical in front, slightly narrower than thorax. Eyes large and subrotundate. Thorax rather broader than it is long, somewhat constricted near the middle, apex slightly rounded, posterior angles obtusely rectangular; distinctly gibbous on the middle, its sculpture close and granular. Elytra rather broader than thorax, their apices individually rounded and not entirely covering the pygidium; with minute, dense, rugose, and granular sculpture, and series of punctures which are regular along the sides but more or less interrupted on the dorsum; on each elytron, near the suture, there is a slight basal elevation, a narrower but more distinct elevation in line with the hind thigh, and a nodosity on top of the apical declivity; in advance of the last, but nearer the side, there is an oblique one; besides these, some smaller asperities are visible.

Antennae elongate, basal joint stout, 2nd short, joints 3–8 inwardly serrate, 9–11 elongate, the 9th being almost as long as the preceding four combined. Tarsi gradually expanded, penultimate joint broadly excavate above, the 5th short and thick, dilated towards the extremity, so as to be of elongate-cordate contour, with thick claws.

Macranobium truncatum (1613) is the only species that is at all similar, but the antennal structure is manifestly different.

Length, 5 mm.; breadth, nearly 2 mm.

Titahi Bay, Wellington. A single mounted specimen from Mr. A. O'Connor, and one, minus legs and antennae, received from Mr. Hubert Simmonds.

3251. Anobium niticolle sp. nov.

Cylindric, nigrescent, legs and antennae rufo-piceous; head and thorax moderately nitid; elytra dull, covered with fine and rather short cinereous pubescence.

Head vertical in front, the occiput closely and minutely punctate. Eyes very prominent. Thorax moderately dilated laterally near the middle, base and apex gently rounded, its length and breadth about equal; there are no superficial inequalities, the middle of the disc is very sparingly punctured, the base distinctly and very closely, the apex much more finely. Scutellum quadrate. Elytra broader than thorax, elongate-oblong, apical margins moderately expanded; they are rather densely and minutely sculptured and rugose, and have numerous series of moderate punctures.

Antennae inserted in front of the eyes; basal joint stout; 2nd much smaller, yet longer than broad; 3rd longer than 2nd; joints 4–10 more or less serrate, each evidently longer than broad; 11th slightly longer than 10th, but hardly as broad as it is. Legs moderately elongate, intermediate femora distinctly thickened at the extremity. Tarsi gradually dilated, basal joint of the anterior as long as the following two combined, 4th deeply and widely excavate above and prolonged more than half-way under the 5th, which is short and thick, with stout, basally thickened claws.

Described from a single specimen mounted on cardboard and smeared with gum, so that all the structural details could not be seen. It is therefore treated provisionally as an aberrant *Anobium*, from which, however, it may be readily separated by the structures of the antennae and tarsi.

Length, 3½ mm.; breadth, 1½ mm.

Silverstream. Discovered by Mr. O'Connor.

Group Opatridae.

3252. Syrphetodes truncatus sp. nov. *Syrphetodes* Pascoe, Man. N.Z. Coleopt., p. 351.

Opaque, dark fuscous, elytral margins slightly rufescent, antennae and legs obscure rufous, tibiae indefinitely maculate, the palpi and terminal joint of the tarsi bright castaneo-rufous; the squamiform setae decumbent, very short, yellowish.

Head with a smooth central spot, the forehead obtusely elevated in front so as to be on nearly the same plane as the antennary orbits; there is no perceptible sculpture. Thorax, in the middle, about a fourth broader than long, anterior angles acute and projecting as far as the centre of the prominent eyes, the apex medially deeply emarginate; its sides slightly sinuate and narrowed before the middle, with a shorter and deeper sinuosity behind, so that the posterior angles seem somewhat acutely prominent; disc obtusely and slightly raised, but not nodose, behind the centre, its sculpture fine and indefinite, apparently granular. Elytra oblong, their sides almost quite straight from behind the shoulders to the hind thighs, curvedly narrowed behind, the apices, nevertheless, are rather broad and obliquely truncate towards the suture, the base is evidently broader than that of the thorax, and there is a slight projection behind each rounded shoulder; their punctation is not quite seriate,

and a little coarser near the suture than elsewhere, their sides have several coarse, smooth foveae; on each elytron there are 4 distinct tubercular elevations; the 1st is basal, near the scutellum, the 2nd before the middle, the 3rd on top of the apical declivity; these are nearly in line; the 4th is placed just outside and a little in advance of the 2nd; there are 4 smaller ones near the 3rd, the innermost pair being near the suture.

Underside fuscous, covered with short tawny setae. Intermediate coxae as far apart as the anterior pair, the posterior slightly more approximated. Basal ventral segment longer than the 2nd in the middle, cuneiform between the coxae, 4th rather shorter than 3rd, 5th simple. Epipleurae broad nearly to the extremity

Antennae with short brassy setae, their basal joint twice as thick but not much longer than the 2nd, which is almost half the length of the 3rd, joints 4–8 about equal; club finely pubescent.

A rather elongated species, with broad, obliquely truncate elytral apices, and unusually brightly coloured palpi.

Length, 12 mm.; breadth, 5½ mm.

Mount Quoin. My specimen was found by Mr. A. O'Connor.

Group Diaperidae.

3253. **Menimus lineatus** sp. nov. *Menimus* Sharp, Man. N.Z. Coleopt., p. 360.

Oblong-oval, slightly transversely convex, nitid; nearly glabrous, there being only a few slender, erect, inconspicuous greyish setae on the hind-body; those on the forehead and legs, however, are more easily seen, as they are more elongate and flavescent; body somewhat infuscate picco-rufous, the lateral margins and apical portion of elytra paler; legs, antennae, and palpi more or less ferruginous.

Head smaller than thorax, finely yet quite distinctly but not closely punctured. Eyes minute. Thorax a third broader than long, very slightly curvedly narrowed anteriorly, nearly straight behind, where the lateral margins are more expanded than they are in front; the apex is bisinuate, with obtuse angles; base subtruncate, closely applied to the elytra, its angles rectangular but not at all prominent; the punctation distant, and rather finer than that of the head; just in front of the fine basal margin and parallel to it there is a fine linear impression which appears more definite when examined sideways. Scutellum broadly triangular, finely punctate. Elytra twice the length of the thorax, of about the same width, but with the rather acute humeral angles extending just outside the hind angles of the thorax; they are gradually narrowed posteriorly, with a corresponding diminution of the lateral margins, which when looked at from above seem quite obsolete; their punctures are subseriate, rather coarser near the sides and suture than those of the thorax, and become indistinct behind.

Antennae stout, rather short; 2nd and 3rd joints rather longer than broad, each evidently longer than the uncovered portion of the 1st; 4th quadrate; joints 5–7 of about equal length, but successively expanded, narrowed towards the base; 8th and 9th large, transverse, narrowed backwards; 10th large, subrotundate.

Legs moderately slender; tibiae with minute terminal spurs; basal joint of posterior tarsi rather shorter than the 2nd and 3rd combined.

In shape intermediate between the elongated *M. oblongus* (656) and *M. thoracicus* (662) and the series of more thickset species, such as *M. crassus*, but separable from these by the linear impression across the base of the thorax.

Length 3½ mm.; breadth, 1½ mm.

Erua. Unique. January, 1910.

Group Helopidae.

3254. Adelium complicatum sp. nov. *Adelium* Kirby, Man. N.Z. Coleopt., p. 386.

Elongate, subdepressed, glabrous, nitid; nigro-violaceous, legs inclusive; antennae and palpi fuscous; labrum fusco-rufous.

Head uneven, irregularly and coarsely punctured, somewhat depressed and coarsely rugose between the eyes. Thorax distinctly margined, a third broader than long in the middle, its sides slightly rounded from the obtuse front angles backwards, but near the base moderately narrowed and nearly quite straight, with rectangular angles; disc with a median linear impression from base to apex but not sharply defined, basal fossae somewhat indefinite and situated nearer to the sides than the middle; its punctation moderate and irregular; there are several slightly raised and depressed spots which cause the surface to appear uneven; the base and middle of the apex are nearly truncate. Scutellum subquadrate, transverse. Elytra more than double the length of thorax, slightly broader than it is at the base, nowhere more than a half broader; the shoulders strongly margined and a little curvate; they are gradually narrowed behind the posterior femora; their sculpture is complex, consisting of smooth, longitudinal, linear and irregularly curved elevations and minutely punctate intervals.

Tibiae stout, curvate externally, the anterior most so near the extremity, the posterior above the middle, but below that part slightly twisted and laterally compressed.

The general contour is intermediate between the parallel-sided series, such as *A. zealandicum*, and the broader *A. bullatum*, with the base of the thorax resting on the elytra. *A. gratiosum* (2055) is a much larger insect. In *A. bullatum* the elytral sculpture consists, to a great extent, of oviform elevations; these are not smooth, being more or less distinctly punctate.

Underside piceous, feebly rugose, basal ventral segment very broadly rounded between the coxae.

Length, 14 mm.; breadth, 4½ mm.

Greymouth. Unique. Secured by Mr. J. H. Lewis over a year ago.

3255. Cerodolus curvellus sp. nov. *Cerodolus* Sharp, Man. N.Z. Coleopt. p. 1161.

Elongate-oval, moderately convex, glabrous, nitid; nigro-aeneous, elytra somewhat iridescent, the legs, antennae, and palpi rufo-castaneous.

Head finely punctate, rather more distantly behind than in front; antennary orbits almost flat. Thorax fully a third broader than long, base distinctly bisinuate, its sides finely margined and gently curved, front angles rounded, the posterior obtusely rectangular; disc finely yet quite definitely but not closely punctured, and with a slight basal depression between the middle and each side. Scutellum short and

broad. Elytra slightly broader than thorax at the base, nearly thrice its length, a little wider just before the middle than elsewhere, considerably narrowed posteriorly, with well-developed margins; each elytron has eight series of moderate punctures, two of these are quite lateral, the three nearest the suture, behind the middle, are substriate; the interstices are finely punctured.

Antennae scarcely as long as the head and thorax, joints 7–11 a little broader and more distinctly pubescent than the others, the exposed portion of the basal joint is much stouter than the 2nd but hardly at all longer, the next is longer than the 4th, the terminal elongate-oval.

In *C. chrysomeloides* the elytral punctures are less numerous and quite foveiform. *C. genialis* (2059) more nearly resembles this species, in which, however, the anterior angles of the thorax are more broadly rounded and the sides almost evenly curved, the elytral punctures are nowhere coarse, and in 2059 the 4th antennal joint is almost as long as the 3rd. The vestiture of the front tarsi is rather dense and nearly grey.

Length, 8 mm.; breadth, $3\frac{2}{3}$ mm.

Advance Peak, Otago. One found by Mr. F. S. Oliver, and sent to me by Professor Chilton. The pygidium is unnaturally distended and uncovered, owing to saturation with alcohol.

Group Anthicidae.

3256. **Cotes insignis** sp. nov. *Cotes* Sharp, Man. N.Z. Coleopt., p. 410.

Elongate, subdepressed, clothed with slender fulvescent hairs, head and thorax shining, dark rufous; elytra, at the base, also rufous, of a pale chestnut-red across the middle, somewhat nigrescent behind, but light red at the apex; the legs, antennae, and palpi rufescent, tarsi yellowish.

Head broader than the thorax, the vertex smooth, with a few indistinct punctures near the eyes. Thorax quite equalling in length the width of its basal portion, deeply constricted behind the middle, in front of the contraction it is subglobose; it exhibits no definite sculpture. Scutellum triangular. Elytra not double the breadth of the thorax, but more than thrice its length; rather finely yet quite perceptibly, but not perfectly seriately, punctured from the base to the hind femora, the posterior sculpture obsolete; there is a slight obtuse elevation on each at the base, and the pale central portion is very slightly depressed; the pygidium is uncovered, and nearly testaceous.

Eyes large, prominent, and distinctly faceted. Antennae stout, distinctly pubescent, reaching backwards to the middle thighs, their 2nd joint nearly as long as the 1st and more than half the length of the 3rd, the 11th scarcely any longer than the penultimate.

C. rufa only, from Mokohinau Island, resembles this species; it is larger, but in 2072 the punctation of the wing-cases is much more distinct, and, before the middle, a broad area is covered with fine golden pubescence.

Length, $5\frac{1}{2}$ mm.; breadth, $1\frac{3}{4}$ mm.

Kaitoke, near Wellington. My specimen is another of Mr. A. O'Connor's novelties. In his specimen fine white hairs almost form a fringe across the dark part of the elytra.

Group: Melandryidae.

3257. Hylobia plagiata sp. nov. *Hylobia* Broun, Man. N.Z. Coleopt., p. 403.

Convex, very elongate oval, slightly nitid, fusco-castaneous, legs and antennae fusco-testaceous, tibiae half fuscous; each elytron with 3 obscure rufo-testaceous spots at the side, behind the middle; pubescence cinereous, very fine, rather dense, and lying close to the derm.

Head of about the same width behind as the apex of thorax, deflexed, with flat eyes. Thorax a little broader than long, slightly rounded laterally, base bisinuate, with a depression between the middle and each side, its surface with minute transversal sculpture, which in some lights appears granular. Scutellum transversely quadrate. Elytra four times the length of thorax, of the same width as it is at the base, wider near the middle, acuminate posteriorly; their suture well marked and slightly rufescent, the sculpture similar to that of the thorax.

Antennae elongate, 2nd joint rather shorter than 3rd, the following joints very gradually and slightly expanded, 9th and 10th subquadrate. Spurs of posterior tibiae closely pectinate, hardly as long as the basal tarsal joint. Anterior tarsi moderately elongate, basal joint nearly the length of the subquadrate 2nd and 3rd taken together, 4th subquadrate, angularly emarginate at apex, 5th rather longer than its predecessor, half its width; claws simple.

Somewhat similar to *H. calida* (715), but readily distinguishable by the more elongate outline, separately acuminate and trimaculate elytra.

Length, 5 mm.; breadth, 1½ mm.

Hayward's, near Wellington. One individual, mounted on cardboard, from Mr. H. W. Simmonds.

3258. Hylobia guinnessi sp. nov.

Convex, very elongate oval, covered with slender, depressed, ashy pubescence, subopaque; head and thorax castaneous, elytra of a chocolate hue, legs fusco-rufous, tarsi and antennae obscure testaceous, the joints of the hinder pairs of tarsi tipped with fuscous, palpi flavescent.

Head finely punctured, rather distantly in front, its breadth about half that of the middle of thorax. Eyes moderately prominent, with coarse facets, gradually obliquely narrowed downwards. Thorax subtruncate at base, its sides gently curved, but, owing to the deflexed angles, appearing much rounded in front; the apex, in the middle, however, is nearly straight; the sculpture is fine on the disc, a little coarser at the sides, but ill-defined; it is a third broader than long as seen from above. Scutellum invisible. Elytra of same width as thorax at the base, but more than thrice its length, a little broader near the middle, attenuate posteriorly; the suture is slightly depressed, their sculpture is rather closer than that of the thorax and equally indefinite; there are no distinct punctures, granules, or transverse lines.

Antennae inserted close to the front of the eyes, their 2nd joint more than half the length and thickness of the basal; 3–5 almost equal, each longer than 2nd; joints 7–10 a little dilated, 9th and 10th as long as broad, 11th slightly larger.

Tibiae with short pubescence, the anterior slightly curved along the inner edge, with a rather thick calcar at the inner extremity; basal joint of the tarsi as long as 2nd and 3rd combined, 4th bilobed and cleft

nearly to the base, 5th as long as the preceding two, with simple slender claws. Spurs of posterior tibiae distinctly pectinate, as long as the dilated tibiae, but shorter than the basal tarsal joint.

The prevailing indefinite sculpture and apparent absence of the scutellum are good distinguishing characters.

Length, 4 mm.; breadth, 1½ mm.

Makatote. Mr. W. J. Guinness, whose name is bestowed on this species, forwarded a package of leaf-mould which he collected near the viaduct in February, 1910. Besides some other rare species, one of this was found amongst the decaying leaves.

[*To be concluded in a subsequent volume.*]

APPENDIX.

RECORDS OF MILNE SEISMOGRAPHS, 1906–1911.

Records of the Milne Seismographs Nos. 16 and 20, taken at Christchurch and Wellington by H. F. Skey and G. Hogben.

Communicated by G. Hogben, M.A., F.G.S.

P_1, first phase; P_2, second phase; P_3, P_4, P_5, large waves. Time is Greenwich mean civil time, given in hours, minutes, and decimals of minutes; 0 or 24R. = midnight. B.P., boom period.

Records of Milne Seismograph No. 16, at the Magnetic Observatory, Christchurch, New Zealand. (Latitude, 43° 32′ S.; longitude, 172° 37′ E. Director, Henry F. Skey, B.Sc.)

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1906.	H. m.	H. m.	Mm.	H. m.	
Jan. 3	2 03·7	2 09·9	0·4	1 10	
„ 4	4 08·7	4 33·5	0·3	0 51	
„ 18	1 35·3	..	..	0 28	Thickening of line.
„ 22	4 16·9	4 23·1	1·5	0 44	
„ 24	7 46·2	..	..	0 49	Thickening of line.
„ 24	22 01·2	22 04·3	0·4	..	End between 22h. 09·4m. and 22h. 13·6m. while attending instrument.
„ 25	1 53·9	..	..	0 16	Slight thickening.
„ 30	..	23 00·5	..	..	Slight swelling.
„ 31	?	16 03·0	15·5	?	? P_2. Beginning and end obscured by tremors.
Feb. 1	2 30·9	..	..	..	
	2 36·1	2 39·2	2·95	..	
		2 42·3	..	1 09	
„ 2	0 21·6	..	..	0 19	Thickening of line.
„ 5	4 29·1	..	..	..	P_1.
	4 33·2	4 34·3	3·45	1 15	
„ 8	0 20·7	..	..	0 52	Thickening of line.
„ 10	9 16·3	9 29·7	0·4	0 22	
„ 12	6 46·2	..	..	..	P_1.
	6 49·3	6 53·4	1·5	0 52	
„ 14	0 40·7	0 45·9	1·0	0 26	
„ 16	23 28·7	..	..	..	P_1.
	23 32·8	23 38·0	1·4	0 56	
„ 19	2 07·2	..	..	..	P_1.
	2 12·4	2 22·7	17·0+	..	
		2 24·1	..	2 54	
„ 20	6 07·2	6 11·8	0·2	0 14	
Mar. 3	?	9 51·3	0·7	?	Beginning and end obscured by night tremors.
„ 8	21 27·5	21 32·7	0·5	0 09	
„ 9	?	19 32·6	5·4	?	Beginning and end obscured by night tremors.
„ 10	6 40·8	..	..	..	
	6 48·1	6 51·2	5·3	?	Beginning and end obscured by night tremors.

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1906.	H. m.	H. m.	Mm.	H. m.	
Mar. 10	16 33·6	16 35·7	8·5	?	Beginning and end obscured by night tremors.
„ 11	3 35·7	3 38·8	0·85	0 36	
„ 11	8 49·1	8 52·2	0·9	0 30	
„ 11	?	21 52·4	0·5	?	Beginning and end obscured by tremors.
„ 20	2 24·8	2 34·1	0·45	?	End obscured by second quake.
„ 20	3 31·0	3 32·5	0·75	..	
		3 33·6	..	0 57	
	(Mean boom period, 15·4 sec. 1 mm. = 0·66″ of tilt.)				
April 14	4 02·9	..	..	..	
	4 07·5	4 11·1	17·0+	1 56	? Origin, New Hebrides.
„ 18	13 33·6	..	..	..	San Francisco. Subsequent tremors at 17 17·6, 18 19·7, 19 20·7.
	14 01·0	14 30·0	6·7	3 21	
„ 19	6 15·4	..	..	..	
	6 21·6	7 10·3	7·0	4 09	
„ 29	6 44·9	6 47·0	0·4	0 38	
May 2	13 18·1	13 24·8	1·4	0 41	
„ 12	8 11·5	8 13·1	0·45	0 21	
„ 13	..	12 01·3	0·55	..	Small, and in middle of night tremors.
„ 15	..	13 23·2	0·5	..	
„ 17	5 28·4	5 34·6	1·2	0 42	
„ 18	23 41·9	23 43·9	0·9	0 28	
„ 19	0 41·9	0 43·9	0·45	0 22	
„ 19	2 31·5	2 32·6	0·4	0 26	
„ 19	..	11 38·8	0·8	..	In middle of night tremors.
„ 21	12 58·8	13 16·9	1·0	0 46	B.P., 15·1 sec.
June 1	4 40·2	..	..	..	B.P., 15 sec.
	5 01·4	5 02·9	3·5	0 43	
„ 2	4 29·8	4 34·0	0·5	0 56	
„ 2	6 28·8	..	..	0 18	Thickening of line.
„ 2	14 43·2	14 48·4	0·9	?	End obscured by night tremors.
„ 5	0 28·0	0 32·2	0·5	0 48	
„ 6	0 00·1	..	..	0 04	Very slight.
„ 9	23 18·6	..	..	0 04	Very slight thickening.
„ 22	?	12 35·2	0·4	?	In middle of night tremors.
„ 24	7 38·1	7 49·5	0·35	0 25	
„ 30	10 21·5	..	..	0 05	Thickening merely.
July 12	10 21·5	10 41·0	0·1	0 42	
„ 12	..	11 21·5	..	..	Very slight thickening.
„ 17	?	15 45·7	0·4	..	Beginning and end obscured by night tremors.
		15 52·9	..	?	
„ 19	8 19·6	8 24·7	0·1	0 18	
„ 22	7 18·7	7 25·9	0·4	0 16	
„ 22	8 14·1	..	..	0 05	Very slight.
„ 23	6 26·2	6 41·6	0·35	0 43	
„ 31	11 32·5	11 39·6	0·45	0 24	
Aug. 3	3 20·3	3 21·8	0·9	0 41	
„ 3	..	4 53·4	..	..	Slight swelling.
„ 5	1 24·0	..	..	..	
	1 27·1	1 28·6	3·4	0 58	
„ 7	22 46·8	22 48·6	0·35	0 11	
„ 8	1 13·6	1 18·8	0·25	0 18	
„ 9	11 20·1	11 23·2	0·6	0 15	
„ 12	6 25·8	6 27·8	0·2	0 14	
„ 12	9 25·8	9 36·0	0·25	0 30	

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1906.	H. m.	H. m.	Mm.	H. m.	
Aug. 17	0 33·3	..	..	..	Valparaiso.
	0 57·3	1 36·1	..	..	Subsequent tremors: 6 33 to 7 14, minute; 7 41 to 8 07, minute; 9 22 to 10 12, minute; 13 23 to 13 25, large; and minute to 14 15·2.
		1 39·8	..	..	
		1 44·4	12·0	4 18	
„ 18	6 56·8	..	..	..	
	7 01·5	7 03·5	1·85	1 39	
„ 22	?	..	..	..	P_1. Beginning and end obscured by continuous tremors.
	19 45·6	19 48·7	5·4	?	
„ 23	1 44·6	1 48·8	0·8	0 21	
„ 23	16 29·6	16 30·6	1·25	?	P_1. Beginning and end obscured by continuous tremors.
„ 26	6 16·7	..	..	..	
	6 30·7	6 34·8	3·3	..	
		6 45·2	..	2 23	
„ 30	3 03·5	..	..	..	
	3 38·7	3 46·5	1·4	1 28	
Sept. 6	19 06·0	..	..	..	B.P., 15 sec.
	19 11·2	19 11·7	2·4	0 10	
„ 14	13 34·8	13 53·0	0·8	?	End obscured by night tremors.
„ 14	16 12·1	..	..	..	
	16 19·3	16 30·2	20·2	..	
		16 31·7	..	..	
		16 35·9	..	?	End obscured by night tremors.
„ 15	2 43·2	..	..	0 03	
„ 16	4 24·2	4 26·8	0·4	0 12	
„ 17	8 52·8	..	..	..	
	9 02·6	9 06·2	3·2	?	End obscured by night tremors.
„ 21	1 28·0	..	..	..	
	1 49·7	1 53·3	1·7	0 27	
„ 21	..	20 08·2	..	..	Minute tremor. Shock noted at 20 10·0 at Christchurch, Cheviot, and Kaikoura.
„ 29	?	14 12·7	0·8	?	Probably night tremors.
Oct. 2	0 10·2	0 13·8	0·3	0 33	B.P., 15 sec.
„ 2	1 59·8	..	..	..	
	2 07·1	2 22·1	17·0+	3 18	Subsequent tremors.
„ 2	?	12 34·0	0·85	?	Possibly night tremors.
„ 2	?	14 51·6	0·85	?	„
„ 3	0 18·1	0 29·4	0·4	..	
		0 45·5	..	1 03	
„ 4	5 06·5	..	..	0 10	Thickening of line.
„ 11	5 18·8	5 36·9	0·4	0 55	
„ 18	3 06·3	..	..	0 19	Thickening of line.
„ 27	3 52·5	4 08·0	0·45	0 30	
„ 29	1 33·9	1 58·5	0·4	0 55	
Nov. 5	23 06·2	23 34·2	0·95	1 16	B.P., 15 sec.
„ 9	?	..	..	..	P_1. Beginning and end obscured by night tremors.
	15 09·6	15 11·5	2·8	?	
„ 10	5 16·2	5 26·5	1·1	0 41	
„ 12	4 12·5	4 14·6	2·5	0 09	
„ 14	?	..	..	..	P_1. Beginning and end obscured by night tremors.
	17 50·2	17 57·9	5·6	?	
„ 19	7 31·0	..	..	..	
	7 39·6	8 01·7	10·0	..	
		8 07·3	..	3 27	
„ 19	22 05·6	22 10·7	1·2	0 52	

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1906.	H. m.	H. m.	Mm.	H. m.	
Dec. 7	23 51·1	23 52·1	0·9	0 12	B.P., 15 sec.
„ 15	3 12·2	..	..	0 29	Thickening of line.
„ 17	22 09·4	22 12·5	0·75	0 59	
„ 18	?	..	..	..	P_1. In middle of continuous tremors
	20 30·1	20 30·6	2·5	..	
		20 35·7	..	?	
„ 19	0 31·6	..	..	..	
	0 36·8	0 44·5	8·5	3 18	
1907.					
Jan. 4	5 31·9	..	..	..	
	5 43·4	6 07·0	4·5	..	
		6 12·2	..	..	
		6 22·6	..	3 55	
„ 7	?	..	..	..	P_1. Beginning and end obscured by night tremors.
	13 59·5	14 02·7	14·0	?	
„ 8	5 42·0	6 21·3	0·5	1 36	
„ 14	9 54·7	9 56·8	1·0	0 37	
Feb. 3	?	..	..	..	B.P., 15 sec. Beginning and end obscured by night tremors.
	20 01·3	20 01·8	2·05	?	
„ 16	21 23·4	..	..	..	
	21 29·1	21 31·7	4·5	1 32	
„ 27	..	9 19·1	..	..	Very small.
		9 21·1	..	..	
Mar. 13	0 46·3	..	..	1 03	B.P., 15 sec. Thickening of line merely.
„ 15	5 08·4	5 10·0	..	0 07	Very slight.
„ 18	7 34·9	..	..	0 10	Minute.
„ 27	0 59·1	..	..	0 32	Minute swellings.
„ 29	6 06·8	6 08·6	1·25	0 08	
„ 31	?	22 13·8	..	..	In middle of night tremors.
		22 17·9	2·5	?	
April 7	9 54·4	10 02·7	..	?	Followed by continuous tremors.
„ 15	6 32·5	..	..	..	
	7 02·0	7 30·9	4·1	2 53	
„ 18	21 11·4	..	..	..	
	21 39·8	21 48·6	1·5	1 39	
„ 19	0 07·2	..	..	..	
	0 32·0	0 36·2	1·5	1 53	
„ 20	2 13·5	2 21·8	1·3	1 14	
„ 22	?	18 10·7	0·7	?	In middle of night tremors.
„ 24	23 40·9	..	..	..	
	24 02·6	24 04·7	1·1	0 58	
May 4	5 58·3	..	..	..	
	6 08·7	6 18·0	2·7	?	End obscured by night tremors.
„ 9	8 29·9	8 33·0	..	0 07	Very slight.
„ 12	?	..	..	..	
	8 04·6	8 06·1	1·1	?	Beginning and end obscured by night tremors.
„ 13	?	..	..	..	Ditto.
	21 23·5	21 26·7	1·9	?	
„ 14	3 50·3	4 02·9	0·45	0 32	
„ 17	1 22·6	1 24·6	0·4	0 09	
„ 23	?	11 21·8	0·4	?	In middle of minute night tremors.
„ 27	5 08·6	..	..	..	
	5 13·5	5 13·8	1·4	..	End obscured by night tremors.
		5 15·8	..	?	
„ 30	?	22 04·9	0·7	?	In middle of continuous tremors.
„ 31	?	..	..	..	Beginning and end obscured by night tremors.
	12 51·8	12 58·0	4·9	?	
June 5	3 46·2	4 23·9	0·4	1 54	

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1907.	H. m.	H. m.	Mm.	H. m.	
June 13	9 57·2	10 10·7	0·7	1 52	
„ 13	12 17·9	12 21·0	0·3	0 18	
„ 18	9 06·3	9 07·9	1·9	0 11	Felt in towns south of Timaru.
„ 19	17 28·6	..	..	0 05	Very small, carrot-shaped.
„ 19	19 03·8	..	..	..	
	19 30·7	19 32·2	1·9	1 34	
„ 27	?	..	..	..	
	22 43·0	22 49·2	6·0±	?	In middle of continuous tremors.
July 18	0 48·1	0 51·2	0·25	0 20	
„ 18	5 06·7	5 10·8	0·8	0 38	
„ 20	..	14 21·5	0·8	..	In middle of night tremors.
„ 29	0 55·7	1 27·3	0·6	0 25	
„ 29	19 51·4	20 11·0	0·4	0 53	
Aug. 4	6 39·1	6 44·8	0·3	1 00	
„ 5	7 02·7	7 04·7	0·3	1 10	
„ 13	21 54·4	..	..	..	
	22 05·7	22 06·8	2·4	1 17	
„ 16	3 57·7	..	..	..	Small, sudden.
„ 18	6 17·6	6 21·7	..	0 15	Swelling.
„ 19	6 09·5	6 16·8	..	0 21	Very small.
„ 23	7 10·0	7 13·1	..	0 28	„
„ 23	13 38·0	13 47·3	0·1	0 23	
„ 28	19 20·8	19 23·9	0·3	0 50	
„ 31	8 43·8	8 48·9	0·3	0 16	
Sept. 2	16 26·3	..	..	..	
	16 54·3	16 55·7	1·5	?	After-tremors for about two hours.
„ 15	5 28·3	..	..	..	
	5 32·9	5 36·6	2·2	1 30	
„ 24	6 00·7	..	..	0 32	Thickening of line.
„ 24	16 58·6	17 03·8	1·4	0 34	
„ 29	5 03·8	..	..	0 08	Swelling.
Oct. 2	1 35·6	2 05·8	1·9	..	B.P., 15 sec.
		2 07·7	..	1 49	
„ 10	?	..	..	..	
	22 05·1	22 05·8	3·5	?	In middle of continuous tremors.
„ 11	?	14 54·9	5·9	?	In middle of night tremors.
„ 17	4 15·6	4 18·1	0·2	0 19	
„ 17	9 00·2	9 02·3	0·4	0 08	
Nov. 3	?	..	..	..	Beginning and end obscured by night tremors.
	18 06·3	18 10·9	2·5	?	
„ 8	12 37·9	12 43·1	0·4	?	Followed by continuous tremors.
„ 8	21 49·3	21 59·7	0·3	0 23	
„ 12	7 10·0	7 14·2	0·9	1 12	Followed by continuous tremors.
„ 13	3 26·7	3 34·9	0·8	1 03	
„ 19	4 54·6	4 59·8	0·9	0 43	
		5 11·7	..	..	
„ 19	21 49·4	22 06·5	0·45	0 45	
„ 21	9 04·9	9 14·8	0·45	0 49	
„ 21	20 48·4	21 12·2	0·6	0 49	
„ 25	0 29·7	0 33·8	0·3	0 36	
„ 26	3 05·8	3 14·0	0·8	0 46	
„ 27	2 06·7	2 09·8	0·35	0 08	
„ 28	3 41·9	3 55·3	0·2	0 27	
Dec. 11	1 09·0	1 27·3	0·6	0 53	
„ 12	22 13·9	22 18·0	0·1	0 06	
„ 15	?	..	..	..	Beginning and end obscured by night tremors.
	17 55·3	18 07·8	4·8	?	
„ 18	1 41·3	1 46·5	0·15	0 09	
„ 23	1 36·6	..	..	0 29	Thickening of line.

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1907.	H. m.	H. m.	Mm.	H. m.	
Dec. 30	6 45·3	..	..	..	
	7 27·8	7 35·5	1·9	2 22	
1908.					
Jan. 19	7 33·7	7 42·0	0·1	0 33	
,, 20	0 46·5	..	..	0 06	Small, carrot-shaped.
,, 24	0 46·8	0 53·0	0·9	0 56	
Feb. 6	1 50·4	..	..	0 37	Thickening of line.
,, 6	6 00·2	..	..	0 06	Small, carrot-shaped.
,, 7	2 56·5	3 00·6	0·15	0 07	
,, 14	1 03·1	1 06·2	0·7	0 24	
,, 24	23 57·8	..	..	..	
	24 01·5	24 02·5	1·6	0 38	
,, 27	0 21·6	..	..	0 03	Minute.
,, 27	9 19·6	..	..	0 44	Swellings.
,, 27	..	12 30·4	1·4	?	In middle of continuous tremors. Maximum appears at beginning of quake.
,, 29	21 49·6	21 55·8	0·4	0 12	
Mar. 5	2 28·8	..	..	..	
	2 52·1	2 59·8	1·6	1 53	
,, 15	?	..	..	..	Beginning and end obscured by night tremors.
	10 19·4	'10 20·4	2·7	?	
,, 19	3 08·1	3 11·7	0·5	0 48	
,, 21	4 25·8	..	..	0 38	Thickening of line preceded and followed by minute tremors.
,, 23	?	..	..	..	Beginning and end obscured by night tremors.
	11 46·6	12 06·2	2·9	?	
,, 26	23 16·3	..	..	..	
	23 27·6	24 09·0	4·25	..	
		24 29·7	..	2 59	
,, 27	4 11·6	4 53·5	0·55	..	
		5 15·2	..	2 07	
April 7	1 26·2	1 37·5	0·5	0 43	B.P., 15·4 sec.
,, 10	0 03·6	..	..	..	
	0 20·0	0 31·8	1·55	1 40	
,, 12	9 09·1	9 14·8	0·1	0 17	
,, 12	19 18·4	19 36·0	0·75	0 40	
,, 15	6 06·1	6 17·4	0·4	0 28	
,, 23	0 07·0	..	..	..	
	0 09·6	0 39·9	1·85	2 05	
May 5	5 28·8	6 03·8	1·0	..	
		6 05·4	..	1 40	
,, 20	8 00·9	8 24·7	0·8	?	Followed by night tremors.
,, 21	7 19·1	..	..	0 15	Slight.
June 3	?	21 25·3	1·0	?	In middle of continuous tremors.
,, 18	1 39·6	1 43·7	0·25	0 14	
Aug. 17	10 50·8	..	..	..	
	10 59·5	11 28·4	5·5	..	
		11 34·1	..	2 44	
Sept. 2	?	21 15·8	0·9	?	Beginning and end obscured by night tremors.
,, 14	3 32·5	3 36·7	0·4	0 19	
,, 21	6 55·7	7 11·8	0·9	1 44	
,, 22	3 11·8	3 23·7	0·35	0 30	
,, 26	5 27·4	..	..	..	
	5 32·0	5 34·1	4·9	1 13	
Oct. 7	1 00·7	1 21·9	0·8	0 46	
,, 13	5 31·0	..	..	1 42	Swellings.

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1908.	H. m.	H. m.	Mm.	H. m.	
Nov. 11	21 22·3	21 30·0	1·0	0 59	Preceded by night tremors.
,, 15	2 00·8	..	..	0 21	Slight swelling.
,, 22	22 52·7	22 58·4	0·25	0 21	
,, 27	0 38·0	0 41·1	0·3	0 24	
,, 30	21 24·1	21 27·2	1·9	0 28	
Dec. 1	3 05·4	..	..	0 38	Swellings.
,, 2	15 12·5	15 15·6	0·25	0 23	
,, 7	2 00·3	2 06·9	0·15	0 28	
,, 8	0 26·1	0 26·4	6·0	..	Severe shock in North Canterbury
		0 27·5	..	0 15	and slight in South Canterbury.
,, 16	..	6 07·7	0·4	..	In middle of continuous tremors.
,, 28	4 40·9	4 55·3			
		5 00·5			
		5 07·8			
		5 20·9			
		5 30·0			
		6 07·2	0·6	2 22	Subsequent tremor at 7 17·1. Origin, Italy.
		6 13·4			
		6 17·1			
		6 20·2			
		6 24·3			
1909.					
Jan. 1	4 11·7	..	..	0 07	Swelling.
,, 3	21 46·5	..	..	..	
	21 51·2	21 52·2	6·4	..	In progress while attending to
		21 54·3	..	0 23	instrument.
,, 17	3 17·9	3 28·2	0·4	0 25	
,, 21	2 38·4	2 47·7	0·5	0 29	
,, 23	3 49·6	..	..	1 37	Tremors.
,, 28	0 38·5	..	..	0 04	Thickening merely.
,, 29	0 59·8	1 15·9	0·3	0 45	
,, 29	?	13 33·4	1·5	?	In middle of night tremors.
Feb. 11	?	..	..	..	Beginning and end obscured by
	18 24·2	18 25·8	2·3	?	night tremors.
,, 22	9 26·7	..	..	..	
	9 31·3	9 37·0	3·4	1 53	
,, 27	?	13 33·4	1·5	?	Beginning and end obscured by night tremors.
Mar. 8	11 45·7	..	..	..	B.P., 15·4 sec. End obscured by
	11 56·0	11 56·5	1·9	..	night tremors.
		11 59·1	..	?	
,, 10	7 37·4	7 38·4	0·45	0 05	
,, 17	23 05·2	..	..	..	
	23 32·3	23 35·9	3·3	3 56	
,, 22	22 05·3	..	..	..	
	22 06·4	22 07·4	17·0+	2 16	Direction N. and S. Felt in southern towns.
,, 26	1 53·8	..	..	0 06	Maximum at beginning. Amplitude very slight. Felt in Christchurch; direction N. and S.
April 10	5 33·4	..	..	..	B.P., 15·5 sec.
	5 43·8	5 45·9	6·0	..	
		5 46·9	..	2 05	
,, 12	1 14·3	..	..	..	
	1 18·5	1 22·6	3·95	1 29	
,, 22	7 14·8	7 15·8	0·2	0 27	
,, 27	12 54·7	..	..	..	
	13 09·0	13 19·3	6·8	2 01	

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1909.	H. m.	H. m.	Mm.	H. m.	
May 2	7 06·1	..	..	..	
	7 12·3	7 15·4	1·9	1 25	
„ 2	..	15 24·4	..	..	Very slight.
„ 2	18 20·3	..	..	..	
	18 25·4	18 29·6	2·5	0 57	
„ 11	?	13 21·7	1·75	?	In middle of air-tremors.
„ 12	0 57·2	1 19·3	0·3	0 55	
„ 17	8 20·2	8 31·0	0·9	1 37	
„ 24	7 13·4	7 17·0	0·5	0 12	
„ 25	4 59·7	5 27·6	1·1	1 08	
„ 30	?	..	..	..	
	21 35·9	21 37·9	2·9	?	Beginning obscured by air-tremors.
June 3	18 52·7	..	..	..	
	19 24·8	19 37·7	2·2	2 52	
„ 8	6 09·7	6 11·8	..	..	
		6 39·7	0·7	..	
		6 55·2	..	..	
		7 13·9	..	?	End obscured by air-tremors.
„ 9	0 51·0	..	..	0 04	Very small ; maximum at beginning.
„ 12	20 25·5	..	..	..	
	20 29·1	20 34·3	7·5	1 36	
„ 14	7 31·1	7 38·4	0·4	0 22	
„ 15	1 19·8	..	..	0 40	Thickening merely.
„ 26	9 35·8	9 36·6	0·1	0 04	
„ 27	7 22·0	..	..	..	
	7 30·3	7 35·5	4·7	1 59	
„ 28	?	15 29·0	0·7	?	Beginning and end obscured by air-tremors.
July 1	13 03·7	13 10·9	0·3	0 28	
„ 2	6 25·9	6 28·5	0·1	0 31	
„ 5	?	17 55·3	3·5	?	Beginning and end obscured by air-tremors.
„ 10	13 40·3	13 42·8	0·4	..	
		14 11·3	..	0 33	
„ 26	22 06·6	22 08·1	..	0 16	Slight thickening.
„ 27	4 34·5	4 36·1	0·2	0 29	
„ 30	11 16·5	11 16·5	0·8	..	First maximum at beginning.
		11 31·2	..	2 34	? Origin, Mexico.
Aug. 4	6 18·3	6 20·4	0·1	0 06	
„ 6	5 46·0	5 49·1	0·4	0 11	
„ 10	6 56·1	7 01·2	0·25	0 22	
„ 13	12 19·7	12 21·7	0·25	0 06	
„ 16	7 54·6	8 17·7	0·4	0 42	
„ 18	0 35·4	..	..	..	
	0 46·2	0 56·4	3·9	0 29	In progress while attending to instrument.
„ 29	23 59·5	..	..	1 34	Thickening of line
Sept. 3	8 11·2	8 18·4	0·35	0 19	B.P., 15·5 sec.
„ 25	12 29·6	12 32·7	0·5	0 14	
Oct. 3	1 28·8	..	..	2 15	Thickening.
„ 4	13 53·2	14 07·0	0·9	?	End obscured by air-tremors.
„ 21	0 45·5	..	..	0 55	Thickenings.
„ 23	?	21 28·9	..	?	Beginning obscured by air-tremors.
„ 27	1 32·3	1 33·3	0·35	0 36	
„ 30	10 33·8	11 02·0	0·9	?	End obscured by air-tremors.
Nov. 3	6 19·0	..	..	..	
	6 23·9	6 25·4	3·25	1 16	
„ 10	5 55·6	..	..	0 11	Thickening of line.
„ 10	6 26·4	..	..	..	
	6 35·6	6 38·2	1·4	1 57	

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1909.	H. m.	H. m.	Mm.	H. m.	
Nov. 12	10 04·4	10 05·7	1·0	0 18	Severe shock; felt in Wellington, New Zealand.
,, 14	9 47·3	9 49·7	0·15	0 07	
,, 27	21 19·1	..	..	0 28	Slight thickening. Possibly air-tremors.
,, 28	1 07·8	..	..	..	
	1 14·5	1 15·6	1·6	1 24	
,, 28	8 28·3	8 34·0	0·5	0 31	Preceded and followed by minute air-tremors.
Dec. 3	3 25·0	3 33·3	0·9	0 40	
		3 34·8	..	..	
,, 8	9 17·6	..	..	..	
	9 23·8	9 25·8	2·1	1 01	
,, 9	?	..	..	..	Beginning and end obscured by air-tremors.
	15 50·6	15 59·1	5·75	?	
,, 9	21 23·3	..	..	..	
	21 27·4	21 31·0	2·0	..	
		21 32·3	..	0 40	? Origin, Ladrone Islands.
,, 9	22 04·0	22 29·0	1·0	1 21	,, ,,
,, 9	?	..	..	..	? Origin, Ladrone Islands. Began while attending to instrument.
	23 49·1	24 03·0	1·4	?	
,, 22	?	..	..	..	
	13 01·3	13 02·8	5·9	?	Preceded and followed by air-tremors.
,, 23	19 30·2	19 36·4	2·3	1 03	
,, 23	22 32·3	22 45·1	1·0	0 58	
,, 28	?	19 56·5	1·0	?	In middle of air-tremors.
1910.					
Jan. 10	?	19 27·8	0·3	?	Beginning and end obscured by air-tremors.
,, 13	0 22·2	0 34·6	0·45	0 42	
,, 15	?	10 58·1	0·65	?	Beginning and end obscured by air-tremors.
,, 15	22 52·9	..	..	0 20	Thickening of line.
,, 19	15 01·1	..	..	..	
	15 07·7	15 09·3	1·5	1 22	
,, 29	5 03·7	5 11·9	1·0	1 01	
,, 30	3 49·2	..	..	..	
	3 52·2	3 54·0	17·0+	2 31	? Origin, Samoa.
Feb. 3	9 57·9	10 05·8	0·75	0 27	
,, 3	?	..	..	..	Beginning and end obscured by air-tremors.
	16 50·7	16 51·9	17·0+	?	
,, 4	14 07·5	..	..	..	
	14 09·9	14 14·2	17·0+	?	End obscured by air-tremors.
,, 4	?	..	..	..	
	14 52·4	14 55·5	5·0 about	?	Beginning obscured by air-tremors.
,, 4	17 44·2	..	..	..	
	17 48·3	17 50·9	2·75	?	End obscured by air-tremors.
,, 4	?	..	..	..	
	18 46·3	18 47·8	1·4	?	Beginning obscured by air-tremors.
,, 6	2 13·7	2 15·2	0·25	0 11	
,, 6	4 41·5	4 45·1	0·2	0 10	
,, 6	7 16·2	..	..	0 21	Thickening of line
,, 7	23 03·2	23 04·7	0·1	0 10	
,, 13	10 04·9	10 08·5	0·45	0 34	
,, 15	1 27·1	1 31·2	0·25	0 31	
Mar. 1	11 37·8	11 44·0	0·5	1 15	

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1910.	H. m.	H. m.	Mm.	H. m.	
Mar. 29	..	8 48·9	0·25	..	Sharp and sudden. Felt at Christchurch.
		8 50·4	0·15	..	
„ 30	17 01·5	..	..	..	
	17 05·6	17 10·0	17·0+	?	End obscured by air-tremors.
„ 30	23 59·4	24 02·7	0·4	0 28	
„ 31	5 37·2	5 40·9	0·2	0 14	
April 1	13 35·3	14 27·8	0·9	1 38·5	
„ 4	5 23·7	..	..	0 08·2	Slight thickening.
„ 8	?	16 55·2	0·9	?	P_1 and duration obscured by air-tremors.
„ 12	0 50·3	0 50·6	1·5	1 04·4	Preceded and followed by minute air-tremors.
„ 13	5 56·6	5 58·7	0·4	0 18·5	
„ 16	?	13 09·3	..	?	P_1 and duration obscured by air-tremors.
„ 18	7 34·9	..	..	0 41·0	Thickening of line.
„ 20	22 28·5	22 49·0	..	1 14·4	Preceded by continuous air-tremors.
„ 23	?	15 52·8	1·3	?	P_1 and duration obscured by air-tremors.
„ 27	2 16·3	..	..	0 35·1	Thickenings.
May 1	4 44·7	4 46·3	0·25	0 11·8	
„ 1	?	18 45·7	5·5	?	P_1 and duration obscured by air tremors.
„ 5	0 57·4	1 09·8	0·2	0 41·0	
„ 6	23 22·9	23 29·1	0·4	0 38·0	
„ 8	18 25·2	18 34·4	0·1	0 20·0	
„ 10	18 32·7	..	..	0 35·4	Small swellings.
„ 13	2 33·6	2 36·2	0·3	0 12·8	
„ 15	4 42·0	4 49·5	0·15	0 26·4	
„ 21	22 58·3	23 07·5	0·2	0 22·5	
„ 22	6 48·1	7 10·6	0·4	1 11·2	
„ 29	8 38·4	..	..	1 26·1	Minute tremors, possibly air-tremors.
„ 29	11 12·2	..	..	0 06·1	Slight swellings.
„ 31	5 19·8	5 21·3	0·15	0 06·6	
„ 31	5 32·6	6 01·8	..	..	
		6 09·3	..	..	
		6 22·9	0·7	1 29·2	
June 1	6 00·7	6 12·5	5·1	3 00·0	? Origin, Fiji.
„ 2	10 30·5	10 32·0	0·2	0 06·1	
„ 5	5 02·6	5 04·6	0·1	0 27·1	
„ 9	6 50·0	..	..	0 05·1	Minute.
„ 9	8 10·5	..	..	0 02·5	„
„ 13	13 08·1	13 13·2	0·3	0 39·5	
„ 23	10 16·6	10 20·7	0·4	0 26·9	
„ 24	2 58·9	..	..	0 14·3	Very slight.
„ 29	10 51·5	11 03·8	..	..	
		11 08·7	17·0+	?	End obscured by quake following.
„ 29	?	14 28·9	4·2	?	P_1 obscured by preceding quake ended 15h. 49·5m.
July 5	10 42·1	10 46·0	1·0	..	
		10 54·4	1·1	..	
		10 59·3	0·9	1 11·0	
„ 7	8 26·8	8 58·7	1·0	..	
		9 14·1	0·8	..	
		9 23·3	1·1	1 57·5	
„ 11	20 36·0	20 39·4	1·2	..	
		20 47·3	1·5	0 53·5	
„ 12	21 08·0	21 12·1	7·0	..	
		21 37·7	3·5	1 47·2	

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1910.	H. m.	H. m.	Mm.	H. m.	
July 15	12 08·5	12 14·0	1·0	..	
		12 21·8	1·0	..	
		12 25·3	1·0	1 19·5	
,, 15	21 48·7	21 51·9	0·2	..	Swellings.
		21 56·7	0·3	0 14·8	Preceded and followed by minute tremors.
,, 19	19 33·5	19 39·3	0·2	..	
		19 52·2	0·2	0 22·0	
,, 24	15 27·7	15 38·9	2·0	0 31·9	
,, 29	10 38·1	11 01·3	2·5	..	
		11 14·3	2·3	1 14·3	
Aug. 5	15 38·3	15 39·5	0·6	0 05·9	
,, 10	20 49·6	21 08·2	0·4	0 38·3	
,, 21	5 36·3	5 53·6	7·0	..	
		5 55·1	5·0	2 31·1	
Sept. 7	7 33·9	7 51·4	7·0	1 25·0	
,, 9	9 00·0	9 19·8	5·1	..	
		9 28·4	3·0	0 55·3	
,, 10	12 21·9	12 33·4	1·4	0 38·3	
Oct. 7	7 05·8	7 11·0	2·4	..	End obscured by air-tremors.
		8 26·5	1·0	0 57·0	
,, 7	11 54·4	12 07·9	2·2	0 53·0	
,, 12	8 00·2	8 06·8	1·0	0 28·6	
,, 18	2 42·5	2 47·7	4·0	1 10·4	
,, 30	7 47·5	7 53·7	2·5	0 51·7	
Nov. 9	6 09·8	6 32·1	17·5	3 03·1	Reproduced.
,, 10	12 28·4	12 40·4	2·0	0 30·6	Duration doubtful owing to air tremors.
,, 26	4 50·4	5 04·8	10·8	..	
,, 26	..	5 49·2	2·0	..	
		4 01·6	2·1	..	End obscured by air-tremors.
		6 38·9	1·5	3 27·7	
Dec. 1	3 52·3	3 55·4	0·6	0 16·5	
,, 2	3 20·2	3 26·4	1·5	0 25·9	
,, 3	7 58·3	8 04·5	16·4	..	
		8 38·0	1·0	1 21·7	
,, 3	4 13·8	4 30·3	0·8	0 21·7	
,, 4	11 05·4	11 10·6	17·0	..	
		11 30·0	3·5	1 45·6	
,, 10	9 37·4	9 47·0	17·5	..	
		10 00·2	5·0	11 36·3	
,, 11	3 57·0	4 04·2	0·7	0 20·5	
,, 12	23 55·9	0 21·7	0·8	0 42·3	
,, 13	12 25·6	12 58·6	1·6	1 16·5	
,, 14	20 54·4	21 02·7	1·5	1 07·3	
,, 16	14 55·3	15 26·3	5·1	..	
		15 41·8	3·5	2 17·6	
1911.					
Jan. 2	22 59·7	23 05·9	14·0	1 52·7	
,, 3	23 46·3	0 26·6	1·4	..	Duration uncertain.
,, 4	..	1 05·9	1·5	2 33·8	
,, 7	2 33·2	3 05·2	1·0	1 13·5	
,, 8	16 24·7	16 27·8	0·8	?	End obscured by air-tremors.
,, 8	9 26·8	9 32·0	2·5	..	
		9 41·4	1·5	0 38·2	
,, 10	16 37·7	16 46·2	7·4	0 55·0	
,, 16	9 08·8	9 37·8	1·0	0 41·4	
Feb. 7	9 42·4	9 46·5	0·8	0 12·4	

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1911.	H. m.	H. m.	Mm.	H. m.	
Feb. 7	9 59·9	10 02·0	0·6	0 10·4	
„ 17	10 14·6	10 29·1	0·5	0 51·7	
„ 17	23 23·9	23 50·8	2·0	0 47·6	
„ 21	23 46·0	23 49·1	0·2	0 07·0	
„ 25	16 12·7	16 17·1	0·8	0 01·5	
Mar. 11	3 29·5	3 43·9	1·5	0 52·7	
„ 17	9 28·2	9 30·3	1·0	0 07·3	
„ 21	4 04·2	4 22·4	0·2	0 42·5	
April 6	9 55·1	10 01·3	0·3	0 14·5	Duration uncertain owing to tremors.
„ 7	7 33·2	7 36·5	0·2	..	
		7 41·6	0·2	0 50·7	
„ 8	2 16·2	2 18·4	0·5	0 09·3	Excellent record.
„ 11	13 40·0	13 41·9	1·5	0 24·0	In middle of tremors.
„ 13	10 14·7	10 18·3	1·1	0 19·6	Excellent record.
„ 15	4 59·9	5 05·0	2·5	..	
		5 13·4	1·6	0 50·5	L.W. commence 5h. 02·5m.
„ 21	2 15·5	2 20·4	1·5	..	
		2 33·0	1·0	1 17·5	
„ 23	12 43·3	12 50·6	2·1	0 23·8	Duration uncertain.
„ 26	1 18·3	1 27·5	0·4	0 59·5	
„ 27	3 03·3	3 04·8	0·2	0 06·9	
May 1	12 27·4	12 32·6	0·3	0 10·3	
„ 20	16 19·6	16 20·4	0·2	0 06·3	
„ 23	4 33·1	4 37·8	0·1	..	
		4 40·3	0·1	0 19·2	
June 3	..	20 39·1	1·5	..	Commencement and duration uncertain owing to tremors.
		20 41·6	2·0	..	
		20 45·6	1·7	..	
		20 47·5	1·5	..	
„ 6	13 05·1	13 06·6	0·5	..	
		13 12·6	0·5	0 18·0	
„ 7	11 17·5	11 31·5	0·7	..	
		12 00·5	1·0	..	
		12 09·5	0·8	..	
		12 14·5	0·8	2 52	
„ 10	17 00·8	17 07·6	1·1	1 14	
„ 12	7 12·6	7 17·6	0·1	0 14	
„ 15	14 36·4	14 46·9	5·5	..	
		14 48·7	4·0	..	
		14 52·4	3·0	..	
		15 04·5	3·8	3 08	
„ 28	19 57·3	19 40·4	1·5	0 28·5	
July 12	4 19·1	4 38·0	2·1	..	L.W. begin 4h. 28·2m.
		4 45·0	4·5	..	
		4 49·3	9·0	3 26	
„ 19	9 02·2	9 05·8	1·2	..	
		9 07·3	1·0	..	End obscured by tremors.
Aug. 6	1 26·0	1 28·6	0·4	0 17·5	
„ 10	0 33·4	0 45·9	0·4	0 31	
„ 16	22 51·2	23 18·3	9·0	..	L.W. commence 22h. 59·8m.
		23 21·7	6·0	..	
		23 23·7	6·0	..	
		23 27·4	6·2	4 40·5	
„ 19	2 21·8	2 24·8	0·3	0 13	Duration approximate.
„ 21	16 38·0	16 41·6	4·0	..	Duration obscured by tremors.
Sept. 6	1 17·9	1 20·7	0·6	1 12	
„ 12	..	14 07·7	1·5	..	Beginning and end obscured by tremors.

Records of Milne Seismograph No. 16—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1911.	H. m.	H. m.	Mm.	H. m.	
Sept. 15	12 25·2	12 25·4	0·6	..	End obscured by following quake.
,, 15	13 44·8	13 48·8	2·0	0 11	
Oct. 5	7 38·9	7 41·3	1·0	..	
		7 44·5	0·5	0 55·4	Shock felt at Hastings, Hawke's Bay, New Zealand.
Nov. 2	0 56·2	1 01·1	2·1	0 33	End uncertain.
,, 16	11 45·9	11 47·9	1·7	..	
		11 49·6	1·8	0 11·3	
,, 30	10 29·2	10 33·2	11·5	0 27	Duration uncertain owing to tremors.
Dec. 3	11 50·3	11 52·0	4·5	0 11·7	
,, 13	12 01·8	12 03·2	0·9	0 01·9	Small local quake.
,, 23	21 52·4	22 09·0	1·1	..	End uncertain owing to tremors.

Note.—Previous to 11th May, B.P. = 14·5 secs. 1 mm. = 0·49″ static tilt.

On 11th May, 1911, the new type of recording apparatus giving a time scale approximately four times as open as the old type, was installed. With this recorder the time scale is 241 mm. to the hour.

After 11th May, B.P. = 16·5 secs. 1 mm. = 0·4″ static tilt.

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Principal Records of Milne Seismograph No. 20, at Wellington, New Zealand. (Latitude, 41° 17′ S.; longitude, 174° 47′ E. Observer, George Hogben.)

(The instrument is placed in a special room below a house standing about 30 ft. from the edge of a rocky cliff about 50 ft. high, situated about 250 yards from the shore-line of Wellington Harbour.)

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1906.	H. m.	H. m.	Mm.	H. m.	
Jan. 10	16 16·3	..	0·6	0 03	B.P., 19·6 sec.
,, 26	8 04·2	..	..	..	P_1. Several previous slight shocks.
	8 21·1	8 21·8	3·8	..	
		8 26·5	..	0 57	
,, 31	15 00·4	..	..	..	
	15 57·6	16 03·3	1·2	3 23	
		16 22·6	..	..	
Feb. 1	2 29·8	..	..	..	B.P., 19·6 sec.
	2 33·9	2 34·2	2·8	0 18	
,, 3	9 55·1	..	8·0	0 04	
,, 19	?	..	..	..	P_1.
	2 17·3	..	..	..	
	2 27·0	2 30·9	10·0	..	
		2 48·0	..	1 45	
Mar. 19	19 24·9	..	..	..	B.P., 19·6 sec. P_1.
	20 04·9	20 06·9	0·6	2 35	Probably Formosa.
,, 28	17 13·2	..	..	..	P_1.
	18 11·5	18 13·8	16·0	..	
	18 24·5	..	..	13 36	
April 5	22 37·8	..	..	..	B.P., 18·7 sec. P_1. Previous tremors.
	22 46·3	22 48·4	1·0	..	
	22 52·8	..	..	?	

Principal Records of Milne Seismograph No. 20—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1906.	H. m.	H. m.	Mm.	H. m.	
April 14	?	..	..	..	B.P., 19·6 sec. P_1.
	3 59·6	..	..	..	P_2.
	4 02·3	4 05·4	7·5	..	
	4 08·1	..	..	?	
„ 18	13 26·6	..	..	..	..
	13 30·1	..	..	..	.. } San Francisco earthquake.
	14 01·9	..	..	..	P_4 }
	14 10·5	14 11·9	9·0	..	P_5 }
	14 39·7	..	..	17 03	End overlapped by beginning of next quake.
„ 19	6 27·3	..	..	..	P_1 ?
	7 06·1	7 08·4	8·5	..	Probably S.E. Asia.
	7 15·1	..	..	1 30	
June 1	4 43·6	..	..	..	B.P., 18·6 sec. P_1.
	4 47·8	..	..	..	P_2.
	5 02·3	5 07·3	2·1	..	
		5 24·0	..	1 12	
„ 2	4 28·1	..	..	..	
	4 30·6	4 33·7	0·6	0 41	
„ 27	0 39·1	..	..	..	P_1.
	1 56·5	2 00·2	0·6	..	
		2 02·1	..	?	
July 15	16 01·2	..	..	..	B.P., 18·5 sec. P_1.
	16 08·8	16 10·6	1·6	..	
		16 15·4	..	?	
„ 17	15 37·3	..	..	..	P_1.
	15 38·9	..	..	..	P_2.
	15 41·0	15 42·8	1·1	..	
		15 49·1	..	..	
„ 18	?	..	..	..	P_1.
	19 42·4	19 43·3	0·5	..	P_3.
	19 48·2	..	..	?	
Aug. 5	1 00·6	..	..	..	B.P., 18·5 sec. P_1.
	1 14·9	..	..	..	P_2.
	1 22·7	1 24·8	1·5	..	
	1 31·4	..	..	3 01	
„ 8	5 13·5	5 14·6	0·5	..	
„ 17	0 27·2	..	..	..	P_1.
	0 33·5	..	..	..	} Valparaiso earthquake; evidently
	1 19·6	1 23·8	18·0	..	} two or three shocks overlap.
		2 03·8	..	29 03	}
„ 18	6 03·9	..	..	..	P_1.
	6 26·3	..	..	..	P_2.
	6 58·3	7 04·7	3·0	..	
	7 08·4	..	..	?	
„ 23	16 23·5	..	..	..	P_1.
	16 26·6	16 29·4	0·6	..	? Calabria.
	16 35·5	..	..	..	
„ 23	19 41·2	..	..	..	B.P., 18·5 sec. P_1.
	20 05·8	..	..	..	P_2.
	21 47·3	21 51·0	0·8	..	
„ 26	?	..	..	..	P_1; obscured by tremors.
	6 30·0	6 35·7	3·2	..	
		6 40·5	..	..	
Sept. 7	19 08·0	..	..	..	B.P., 18·5 sec. P_1.
	19 41·7	19 54·3	1·0	..	
„ 14	13 41·3	..	..	..	? Obscured by tremors.
	16 12·8	..	..	..	P_2 ?
	16 27·1	16 30·9	20·0+	7 36	B.P., 15·9 sec.

Principal Records of Milne Seismograph No. 20—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1906.	H. m.	H. m.	Mm.	H. m.	
Oct. 2	1 58·6	..	..	..	B.P., 18·5 sec. Probably Indian Ocean.
	2 04·6	..	..	..	
	2 15·1	2 19·9	13·0	2 31	
„ 15	?	..	..	..	P_1.
	13 27·9	?	2·5	?	Obscured by tremors.
„ 21	2 05·1	..	..	..	P_1.
	2 17·6	2 19·9	13·0	1 56	
„ 29	1 39·8	..	..	..	P_1.
	1 52·4	1 53·6	1·4	?	Obscured by tremors.
„ 30	19 13·7	..	..	..	
	19 18·5	19 19·4	1·0	..	
	19 23·6	..	..	..	
Nov. 6	20 06·1	..	..	..	B.P., 18·5 sec. P_1.
	20 17·2	20 20·5	2·1	..	
	20 36·9	..	..	..	
„ 14	17 22·4	..	..	..	P_1.
	17 47·2	17 50·6	7·8	..	
	18 10·6	..	..	5 25	
„ 19	7 27·5	..	..	..	P_1.
	7 35·2	..	..	..	P_2.
	7 48·0	7 53·1	10·5	..	
	8 05·3	..	..	..	
	8 14·3	..	..	3 13	
1909.					
Mar. 17	23 17·4	..	..	..	Or P.T. commence 23 12·8, or even
	23 27·2	23 30·4	6·0	1·24 about	23 05·0.
April 10	5 40·9	..	..	..	
	5 49·9	5 51·0	5·6	2 42	
May 30	21 20·1	..	..	..	Repeats at 23 55·1, 24 53·5, 25 19·8,
	21 32·2	21 35·5	4·0	..	26 26·0, &c.
June 11	10 09·4	..	..	..	
	11 02·1	?11 16·8	0·5	2 02·6	S. France.
		11 40·4	0·5		
Nov. 3	6 21·7	6 26·5	2·0	0 15	Tremors before and after.
Dec. 9	15 45·2	..	..	..	
	15 55·8	15 58·6	4·5	..	
1910.					
June 1	5 30·1	..	..	..	B.P., 13·5 sec. P_1.
	5 40·2	5 43·7	7·5	1 27	S.W. Pacific, near New Hebrides.
„ 16	6 34·1	..	..	1 40	Probably S.W. Pacific, about 450 miles north of New Zealand.
	6 45·2	6 49·3	14·5	..	Followed by tremors and repeats until 5 55 on 17th June.
„ 29	10 50·5	..	..	..	Origin, 11° S., 172° E.
	11 02·8	11 06·9	12·5	2 14	
„ 29	14 24·8	..	..	..	
	14 27·8	14 29·5	9·0	1 38	Origin, 51° S., 173½° E.
July 29	10 43·7	..	..	..	P_1.
	10 52·3	..	..	..	P_3.
	10 57·4	10 58·0	3·0	..	P_5.
Aug. 18	12 40·5	..	..	..	P_1 Local.
	12 41·1	..	1·0	..	P_3 Local.
„ 31	21 49·5	..	..	17 40	Almost continuous tremors.
Sept. 7	7 04·5	..	..	..	P_1
	7 11·7	..	..	..	P_2 Origin, 32° S., 179° W.
	7 28·7	..	..	..	P_3
	7 34·8	7 39·4	4·0	..	P_5

Principal Records of Milne Seismograph No. 20—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1910.	H. m.	H. m.	Mm.	H. m.	
Sept. 9	9 13·4	..	..	..	P_1.
	9 19·2	..	..	..	P_3.
	9 25·2	9 27·4	1·8	..	P_5.
Oct. 18	2 33·8	..	..	..	P_1.
	2 42·3	2 44·5	2·8	..	P_3.
	2 49·5	..	..	..	P_5.
Nov. 9	6 07·3	..	..	..	P_1 }
	6 11·4	..	..	..	P_2 }
	6 13·3	..	..	..	P_3 } Origin, 17° S., 167° E.
	6 15·4	..	..	..	P_4 }
	6 18·6	?	17·0+	..	P_5 }
,, 26	4 46·5	..	..	..	P_1 }
	4 51·2	..	..	..	P_3 } Origin, 5° S., 165° E.
	4 54·8	4 56·1	17·0+	..	P_5 }
Dec. 10	9 38·1	..	..	..	P_1 }
	9 41·7	..	..	..	P_3 } Probable origin, 2° N., 146° E.
	9 44·9	9 46·5	7·0	..	P_5 }
,, 13	12 03·2	..	..	..	P_1.
	12 37·5	12 49·8	6·3	..	Probably P_5 or P_3.
,, 16	14 56·2	..	..	..	P_1.
	15 09·0	..	..	..	P_3.
	15 25·3	15 27·5	15·3	..	P_5.

NOTE.—1 mm. of amplitude = 0·70″ of tilt (static).

1911.					
Jan. 2	22 53·4	..	..	}	B.P., 18·3 sec.
	22 59·2	..	..	} 0 41	Distance, about 2,100 km.
	23 01·4	23 04·1	12·3	}	
,, 3	2 24·7	..	..	..	
	2 59·7	..	..	..	
	3 32·0	..	0·5	..	
	3 48·5	..	0·6	..	
	4 27·3	..	..	..	
,, 3	23 51·6	..	..	..	P_1 }
	24 14·5	..	..	..	P_2 ? }
	24 28·2	..	..	..	P_3 ? } Turkestan.
	24 42·7	..	..	..	P_4 ? }
	24 45·2	24 46·7	4·0	..	P_5 }
,, 9	17 43·0	17 43·5	0·6	1 02	Local. Principal shock, 2·3 sec., Rossi-Ford, V.
,, 10	16 35·9	..	..	}	P_1 }
	16 37·1	..	..	} 0 24	P_2 } Distance, about 1,200 km.
	16 38·6	..	..	}	P_3 } B.P., 20·7 sec.
		16 40·8	2·2	}	P_5 }
April 17	23 08·0	..	..	}	P_1 }
	23 10·9	..	..	} 0 10 about	P_2 } Distance, about 1,500 km.
	23 12·6	..	..	}	P_3 }
	23 13·8	23 14·4	3·0	}	P_5 }
,, 21	2 16·2	..	..	}	P_1 }
	2 17·4	..	..	} 0 22 about	P_2 } Distance, about 1,150 km.
	2 19·2	..	..	}	P_3 }
	2 20·5	2 22·5	1·4	}	P_5 }
May 4	14 01·4	..	..	}	
	14 04·4	..	..	} 0 21	Distance, about 2,100 km.
	14 09·7	14 12·8	1·0	}	
,, 5	23 59·0	..	..	}	P_1 }
	24 22·4	..	..	} 1 02	P_3 } Distance, about 8,000 km.
		24 28·9	1·5	}	P_5 } B.P., 19·5 sec.

NOTE.—1 mm. of amplitude = 0·70″ of tilt (static).

Principal Records of Milne Seismograph No. 20—continued.

Date.	Commencement.	Max.	Max. Amplitude.	Duration.	Remarks.
1911.	H. m.	H. m.	Mm.	H. m.	
June 7	11 27·8	..	..		B.P., 18·4 sec. P_1.
	11 49·8	..	..		P_4.
	11 53·7	11 56·2	13·0	2 30	P_5. Long waves.
	12 03·9	..	..		P_8. Probably transverse waves.
					Origin, Mexico. Times uncertain.
,, 10	16 59·1	17 00·1	1·2	0 07	? Local.
	17 04·1	17 05·2	0·8		
,, 16	14 30·2	..	..		
	14 32·4	..	..	3 07	Beginning obscured by tremors.
	14 47·9	14 49·3	8·0		
,, 21	16 33·9	..	..	..	
	16 43·6	16 44·9	2·5	0 44	
July 12	4 18·6	..	..	..	B.P., 17·5 sec. P_1.
	4 49·2	4 51·3	8·0	1 08	P_5.
Aug. 16	22 51·4	..	..		B.P., 17·0 sec. P_1.
	23 00·0	..	..		P_2.
	23 12·8	..	..	3 18	P_3.
	23 15·7	23 16·7	7·0		P_4.
	23 19·5	23 22·2	10·0		P_5.
Oct. 5	7 36·7	7 37·5	..	..	B.P., 12·5 sec. Origin, about 200–250 miles east of Wellington.
		7 39·0	..	..	
,, 17	9 41·9	9 46·4	2·0	0 36	? Origin, about 550 miles from Wellington.

PROCEEDINGS.

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1911

PART I

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NEW ZEALAND INSTITUTE.

1911.

PART I.

PROCEEDINGS.

WELLINGTON PHILOSOPHICAL SOCIETY.

FIRST MEETING: *10th May, 1911.*

An ordinary meeting of the society was held on Wednesday, 10th May, 1911, in the Dominion Museum.

Mr. G. V. Hudson, President, in the chair, and about fifty present.

New Members.—Mr. L. Birks. B.Sc., Assoc.M.Inst.C.E. (transfer from Auckland Institute), Mr. F. J. Carter, M.A., Mr. J. W. Salmond, M.A., Mr. W. J. Anderson, M.A., LL.D., and Mr. W. H. Morton, M.Inst.C.E.

Eugenics Education Society.—Reference was made by Professor Kirk and the President to the meeting called for 11th May, to form an Eugenics Education Society in Wellington.

Presidential Address.—"The Value of Natural-history Studies." By G. V. Hudson, F.E.S.

ABSTRACT.

The lecturer used the term "natural history" to mean the study of nature in the broadest sense, the object being the extension of human knowledge and happiness apart entirely from commercial and economic interests, and he stated that the growing tendency to judge every sphere of action on its commercial value was distasteful to him. Although children often take a very keen interest in natural objects, the majority of adults are absolutely indifferent to the wonders and beauties around them. This loss of interest he attributed to the influences, both at home and at school, directing the attention of children to other studies which are commonly supposed to enable them to get on in life—though, as Herbert Spencer long ago pointed out, a knowledge of the laws of life is more important than any other knowledge whatever. Although to many persons a naturalist is a dreamer who is more or less incompetent to deal with the problems of life, yet the qualifications required for a successful naturalist, such as keenness of observation, accuracy, continuity of purpose, &c., are precisely those most required in business, and many well-known naturalists have been also successful business men. The study of natural phenomena exercises the powers of observation and also the memory, while many of the subjects in the school curriculum exercise the memory only. Natural history also acts as an antidote to the dullness and ennui that is apt to overcloud middle life when the brightness and originality of childhood have departed, and, further, it leads the student to the consideration of the deepest questions of philosophy—questions bordering on religion, which are perhaps unwisely excluded from the scope of the Institute.

Examples of the ignorance of natural phenomena displayed by persons supposed to be well educated were given, and it was pointed out that mistakes in such matters are usually thought little of, while a man who makes a slight slip in spelling or grammar is branded as an ignoramus.

If the conclusion of many naturalists that acquired characters are not inherited is correct, it follows that the labour expended on education is for each generation only; and, though this may be a disappointing doctrine to those who have believed that the race could be improved by the inherited effects of education, there is a brighter side to the question, for if the absence of men of commanding personality at the present time is due to the repression of individuality during early years, we may reasonably anticipate that with improved and more enlightened methods of education and a more suitable environment men of commanding personality will again arise. Some signs of the growing dissatisfaction with many of the present educational methods, and of greater attention being paid to natural history, were noted with approval, and in connection therewith the lecturer made the following suggestions :—

(1.) That young members might be induced to join the society as associates, and on payment of a small fee be entitled to all the privileges of membership except the annual volume.

(2.) That further efforts should be made to secure closer and more united action between the various branches of the Institute.

(3.) That special efforts should be made to place the New Zealand Institute more on the same status as the Linnean, Geological, and other learned societies, so that its members might be termed "Fellows of the New Zealand Institute."

(4.) That in addition to its present functions the New Zealand Institute might with advantage promote the objects pursued by the Selborne Society of the United Kingdom, such as the preservation of such wild animals as are harmless, beautiful, and rare, the protection of places and objects of natural beauty or antiquarian interest, &c.

(5.) The formation of sections for special subjects, and the closer co-operation of the similar sections of the different branches of the Institute.

Papers.—1. "Some Effects of Imported Animals on the Indigenous Vegetation." By B. C. Aston, F.I.C., F.C.S. (See p. 19.)

2. "Notes on Nests, Life-history, and Habits of *Migas distinctus*." By J. B. Gatenby.

Astronomical Section.—The following report of the Astronomical Section was presented :—

REPORT.

The Astronomical Section of the Wellington Philosophical Society was formally constituted at a special meeting held in the Museum on the 22nd August, 1910.

At present the section consists of thirty-two members, with the following officers: President and Treasurer, Mr. C. P. Powles; Director and Curator of Instruments, Rev. Dr. Kennedy; Council, Professor D. K. Picken, Dr. C. M. Hector, and Messrs. C. E. Adams, G. Hogben, W. S. La Trobe, and A. C. Gifford (Secretary).

On the 29th September the Rev. Dr. Kennedy gave a popular lecture on astronomy, in aid of the Observatory Fund, which resulted in a net profit of £18 6s. In this connection we must thank the City Council for kindly granting us the free use of the Concert Chamber in the Town Hall.

The following is a list of the papers read and lectures delivered at the ordinary meetings of the section :—

October 11.—Presidential Address on Astronomy.—Mr. C. P. Powles.

November 15.—The Pressure of Light.—Professor T. H. Laby.

February 21.—The Mechanism of Astronomical Instruments.—Mr. W. S. La Trobe.

April 11.—Spherical Geometry and Trigonometry.—Professor D. K. Picken.

It is proposed to start an astronomical library in connection with the section. We must thank Dr. C. M. Hector for astronomical catalogues presented for this purpose, and Mr. J. Grigg, F.R.A.S., for a photo of Halley's Comet, 1910, taken by himself at the Observatory, Thames.

A number of members have sent to the Secretary lists of the astronomical works in their private libraries, which may be of great use to members when searching for information on particular points.

The solar eclipse: The Council endeavoured to organize a party to co-operate with the Australian Eclipse Expedition. Unfortunately, owing to the short time available for making arrangements, the long time the expedition would take, and the considerable expense involved, they were unsuccessful in this attempt.

The section is very deeply indebted to Mr. A. Hamilton, Director of Observatories, for his kindness in placing at our disposal a fine 5 in. Cooke telescope, and for granting the use of a portion of the Time Observatory site at Kelburne for storing, and observing with, the same. The telescope has been moved to Kelburne, and is now available for the use of members, but we hope that it will be much more conveniently so before very long. Nearly five months ago the Council ordered from England an equatorial mounting for it. This should very soon arrive in Wellington, so immediate steps must be taken to provide for the housing of the instrument.

The principal object of the section is to promote and encourage in every possible way the study of astronomy. As one of the chief means to that end the section is striving to secure the speedy establishment in or near Wellington of a fully equipped astronomical observatory. It is felt that progress in this direction will be slow unless public interest in astronomy can be aroused. It is proposed, therefore, as soon as the telescope is mounted and housed, to give those who desire it an opportunity of seeing some of the wonders of the heavens.

Unfortunately, the section as constituted has no direct and permanent source of revenue. Membership of the Philosophical Society carries with it the right of membership of the section without any additional subscription. The section started with nothing, and although there is now £34 12s. in the savings-bank it is in urgent need of further funds. The equatorial mounting ordered from England is catalogued at £33 without some extras that were found essential, and, of course, the mounting will be useless unless the telescope is adequately housed. Subscriptions for this purpose would be very welcome now. When the section was constituted Dr. C. M. Hector opened the Observatory Fund with a donation of £10. This was followed by donations from Miss Helyer, and Messrs. J. P. Firth, W. H. Carter, jun., J. Thompson, and A. C. Gifford. The total subscriptions up to the present amount to £16 6s., which with the £18 6s., the net proceeds of Dr. Kennedy's lecture, makes up the £34 12s. already referred to.

The question of the best way to house the telescope was discussed at the last meeting of the section, and is at present a matter for the serious consideration of the Council.

Several interesting papers are promised for the forthcoming meetings, so, with the increased interest that will doubtless be aroused by the facilities for observation that will soon be provided, the section can look forward with confidence to a successful season's work.

A. C. Gifford, Hon. Secretary.

Special Meeting: *18th May, 1911.*

A special meeting of the society was held on Thursday, 18th May, 1911, at Victoria College.

Mr. G. V. Hudson, President, in the chair, and about seventy present.

Lecture.—Professor T. H. Laby delivered an interesting lecture on the principles of gyroscopic motion, and showed a number of experiments with gyroscopes and a model of the Brennan mono-rail car, which had been built in the physics laboratory.

All the experiments were most successful, and when the requisite speed had been attained by the gyroscopes of the car it was run over a wire stretched across the room, and maintained its equilibrium in spite of tiltings and repeated shakings of the wire.

Mr. G. Hogben, Inspector-General of Schools, moved a vote of thanks to the lecturer, and remarked on the interesting manner in which Professor Laby had explained one of the newest developments of mechanics.

Mr. A. L. Beattie, Chief Mechanical Engineer to the Railway Department, seconded the motion, and said that as a railway engineer of forty-five years standing he had been particularly interested in the professor's exposition.

The motion was carried with great heartiness.

Second Meeting: *7th June, 1911.*

The second ordinary meeting of the society was held on Wednesday, 7th June, 1911, in the Dominion Museum, Wellington.

Mr. G. V. Hudson, President, in the chair, and about eighty present.

New Members.—Mr. J. Henderson, M.A., D.Sc., Mr. W. E. Spencer, M.A., M.Sc., Mr. G. Stuart Thomson, and Mr. J. Allan Thomson, B.Sc.

The President, referring to Kapiti Island, announced that the society would make strong representations to the Government to reserve the whole island for Native fauna and flora.

Papers.—1. "Further Note on *Migas distinctus*." By J. B. Gatenby.

2. "Othello." By H. L. James, B.A.

Mr. James delivered an interesting address on Othello, and during the evening Mrs. B. M. Wilson sang Desdemona's song to the original music.

3. "Maori Curiosities." By Dr. A. K. Newman.

Dr. Newman described and exhibited Maori curiosities collected recently.

4. "The Nature of Gamma Rays." By Professor T. H. Laby and P. W. Burbidge, B.Sc. (See p. 30.)

Third Meeting: 12*th July*, 1911.

The third ordinary meeting of the society was held on Wednesday, 12th July, 1911, in the Dominion Museum, Wellington.

Mr. G. V. Hudson, President, in the chair, and about forty present.

New Member.—Professor Garrow.

Exhibits.—1. Mr. A. Hamilton, Director of the Museum, exhibited some recent acquisitions to the Museum, including two collections of *Lepidoptera*, one from Brisbane in exchange for New Zealand specimens, and the other from Aru Island on the south-west coast of New Guinea.

2. On behalf of Professor Laby, who was unable to attend, Mr. P. W. Burbidge, B.Sc., exhibited and explained the action of a vibration galvanometer.

Address.—Mr. R. W. Holmes, Engineer-in-Chief, Public Works Department, delivered an interesting address on the "Federal Capital Territory," and illustrated his remarks by means of numerous plans—contour, meteorological, geological, &c.—panoramic views, and a large relief model of the locality in which Australia's capital city is to be built.

Paper.—Professor T. H. Easterfield read a paper on the "Higher Fatty Acids," and described experiments made by himself and Miss C. M. Taylor; and exhibited and described the apparatus used.

AUCKLAND INSTITUTE.

FIRST MEETING : *12th June, 1911.*

Mr. J. H. Upton, President, in the chair.

New Members.—Messrs. A. W. Clark, F. N. R. Downard, T. Ellison, Edwin Hall, J. W. Hall, R. D. Gunson, Dr. R. H. Makgill, Dr. Milsom, Dr. Rossiter, Rev. D. D. Scott, Mrs. R. H. Shakespear, J. J. Walklate, and S. Walker.

The President delivered the anniversary address, taking as his subject "Free Public Libraries and Museums."

He made a reference to the public libraries of ancient times, and to the people who possessed them. Some remarks were given on the libraries of the present times. Consideration was given to the best methods of maintaining libraries, and the dangers were described that are likely to follow upon the injudicious admission of inferior books. He held that the main purpose of a public library should be educational. Museums were regarded as institutions supplementary to public libraries. A reference was made to several well-known public museums, and an outline was given of what a museum may be.

MANAWATU PHILOSOPHICAL SOCIETY.

FIRST MEETING: *16th March, 1911.*

Captain Hewitt, R.N., in the chair.

Lecture.—"Ramblings and a little Philosophy." By H. B. Drew.

The lecturer gave interesting reminiscences of a two-years cycling tour on the Continent of Europe and in the Holy Land, and illustrated them by lantern-slides from sketches and photographs by Mr. G. E. Woolley. He took his hearers—mostly by by-ways—through parts of Italy, France, Austria, Switzerland, Denmark, and Germany, as well as Jerusalem and its neighbourhood, giving his impressions of the cultivation of the land and the condition of the peasantry in the different countries. He was much struck, he said, by the great cordiality with which he and his companions were received throughout their travels, especially in Austria and Germany, and by the high opinion apparently everywhere entertained of England and English honour.

SECOND MEETING: *20th April, 1911.*

Mr. J. E. Vernon, M.A., in the chair.

Papers.—1. "The Anatomical Structures of the New Zealand *Piperaceae*." By Miss A. F. Ironsides, M.A.

This paper gives in full detail the results of an examination of the anatomical structure of the adult plant and seedling of the New Zealand representatives of the *Piperaceae*, and discusses the bearing of the facts on the relationships of the order and on the phylogeny of the Angiosperms generally.

2. "Some New Zealand Moths." By the Rev. A. Doull, M.A.

Illustrated by a collection of about forty species showing curious individual variations, including *Bityea defigurata*, found only at Palmerston North, in the North Island.

3. "Moose and Wapiti in New Zealand." By R. Henry.

The writer stated that these animals, which had been brought from Canada, where they had abundance of grain and sunshine, enabling them in the summer to put on sufficient fat to carry them through the winter, while the weaklings were carried off by the wolves, had been turned out in a valley in the Sounds, where there was neither grass nor sunshine, and almost perpetual rain, with sides so steep that it was hardly possible for them to get out of it.

4. "Pike as Health Officers." By R. Henry.

Showing by an illustration in the *Sporting and Dramatic News*, and by statistics from English papers, that pike by structure and habit are adapted for the capture of sickly fish only, and are therefore most useful as health officers, and that the same function is discharged in New Zealand by eels, and probably also by shags.

THIRD MEETING: *6th June, 1911.*

Mr. W. S. Durward in the chair.

Mr. Justice Chapman gave a very interesting lecture on the "Alpine Flora of New Zealand." He began by defining "alpine flora" as that which prevailed above the forest-line, but pointed out that the altitude of this line, here as elsewhere, gradually decreased from the Equator towards the Poles, sinking from 4,000 ft. in the North Island and Nelson to the sea-level in the Campbell Islands. There was great similarity in the alpine flora all over the world; the chief distinction of the New Zealand variety was that it was almost entirely white, especially in the higher regions. This flora was of great beauty, and was to be found in great profusion in the higher parts of the Tararua and Ruahine Ranges and on Ruapehu, as well as in the larger alpine areas of the South Island. The existence of this alpine flora in conjunction with the almost tropical forest rendered it probable that New Zealand had at one time been connected with a large continent extending as far as New Guinea, and at another time with the Antarctic. He warmly recommended the study of the New Zealand alpine flora to all who desired healthful recreation, as the regions where the alpine flora prevailed were now easily accessible from all parts of the Dominion.

At the conclusion of the lecture a cordial vote of thanks was moved by Mr. Wilson, and seconded by Mr. Vernon.

OTAGO INSTITUTE.

FIRST MEETING: *2nd May, 1911.*

The President, Mr. A. Bathgate, in the chair.

Technological Section.—The President announced that the newly formed Dunedin Technological Society had affiliated itself with the Otago Institute, members of the society becoming full members of the Institute, with the right to form a Technological Branch with control of its own lectures and proceedings, and with power to select a chairman and officers to manage the same.

New Members.—Professor (Miss) W. E. Boys-Smith, Mrs. Montgomery Spencer, Messrs. J. N. Lawson, C. Parr, H. D. Skinner, D. L. Poppelwell, A. Walker, and R. W. Rutherford.

The following sixty-five members of the Technological Society were also elected members: Dr. W. Newlands, Messrs. E. W. Ackland, L. O. Beal, D. E. Booth, H. Brasch, H. C. Brent, F. R. Brown, Ross Burt, W. E. Chisholm, B. B. Couston, E. C. Creagh, R. E. Davidson, W. R. Davidson, G. W. Davies, C. Duke, G. C. Edgar, K. Edge, M. Elliot, G. Ferguson, P. Findlay, A. C. Forsyth, H. V. Fulton, Joseph Fulton, C. Frye, G. W. Gough, H. J. Gould, M. C. Henderson, G. T. V. Hobart, B. B. Hooper, J. T. Hungerford, S. H. Howrth, R. C. Jones, A. Lambie, G. A. Lee, F. J. Lough, J. Lythgoe, W. L. McEvoy, D. McKenzie, H. McRae, W. P. Macdougall, jun., Angus Marshall, Watson Munro, Alex. Neil, T. R. Overton, R. V. Parker, T. A. C. Preston, T. C. Ross, J. H. Scott, F. M. Shortt, D. Sherriff, George Simpson, George Simpson, jun., F. W. Skelsey, J. A. Smith, R. E. Stark, J. Stark, James Stark, H. Symes, S. Symington, R. S. Thompson, R. N. Vanes, R. D. Veitch, T. S. Wansbrough, P. Y. Wales, and E. W. Walden.

Address.—Mr. Bathgate then delivered his presidential address, entitled "Some Neglected Aspects of Afforestation."

ABSTRACT.

The lecturer dealt with some of the more neglected aspects of afforestation, and pointed out that in addition to the primary object—*i.e.*, the production of timber—the other benefits of afforestation were chiefly two—(1) climatic, and (2) conservancy of the water-supply. The climatic effects were increased rainfall and shelter. The connection between forests and the rainfall was fully considered, and in opposition to the opinions of many modern writers it was urged that the presence of forests on mountain-slopes probably favoured precipitation from clouds that would otherwise pass over causing only mists, and that even where they do not increase the actual rainfall, forests affect the distribution of rainfall. The climate of Central Otago and its possible alteration by afforestation was fully considered under this head. The beneficial effects of forests in affording shelter and equalizing the temperature were described at some length, and special attention was drawn to the beneficial effects of tree-planting in Jutland. The lecturer then dealt with the effects of forests in minimizing floods and in retaining the

moisture of the soil, and numerous examples were given from different countries of the effects of deforestation in drying up springs and producing desert conditions. The appointment of a thoroughly trained scientific forester in New Zealand to control all existing natural forests and to direct the formation of artificial forests was strongly urged, and it was argued that though afforestation on a more extensive scale than at present would lead to additional temporary expenditure, it was a duty that we owed to our descendants, and that eventually it would yield handsome profit.

At the close of the address several members spoke instancing cases of deforestation in various parts of Otago, and the following resolution was moved by Mr. J. N. Lawson, and carried unanimously: "That this Institute respectfully urge upon the Government the urgent necessity for a more vigorous prosecution of the work of afforestation throughout the Dominion, and that, notwithstanding its vast importance, the production of timber should not be the sole object of the forestry operations, but climatic considerations and the conservation of water should also be dealt with; and this Institute would also further urge upon the Government the necessity for appointing without delay a scientifically trained Chief Forester to direct and control the Department."

SECOND MEETING: *6th June, 1911.*

Mr. A. Bathgate, President, in the chair.

New Members.—Miss Edith Howes, of Gore, author of "The Sun's Babies," was elected an honorary member. Dr. P. D. Cameron, Dr. A. J. Hall, Captain S. G. Sandle, and Messrs. W. D. R. McCurdie, F. A. Simpson, Nelson Jones, F. Oakden, C. H. Marriott, C. H. N. Thomlinson, K. A. McDonald, F. R. Shepherd, W. J. Mitchell, A. Mackie, W. J. Scoullar, W. J. Crawford, G. J. Orchiston, and H. C. Auty were elected members.

Papers.—1. "On the Nomenclature of the *Lepidoptera* of New Zealand." By G. B. Longstaff, M.A., M.D., F.E.S.; communicated by Mr. G. W. Howes, F.E.S.

2. "Notes on the Nomenclature of the New Zealand *Geometridae*." By L. B. Prout; communicated by Mr. G. W. Howes, F.E.S.

3. "New *Lepidoptera*." By L. B. Prout; communicated by Mr. G. W. Howes, F.E.S.

4. "Life-history of *Argyrophenga antipodum*." By G. W. Howes, F.E.S.

5. "The Food-value of Oysters." By Professor J. Malcolm, M.D.

The author stated that he had recently been investigating some of the food-products of New Zealand, and particularly oysters. One of the great principles of diatetics was that the food should supply a sufficient amount of combustible matter in the body to supply heat and energy. He referred to the three divisions of foodstuffs—fat, protein, and carbohydrates—and to the quantitative and qualitative ways of looking at food. New Zealand oysters contained from 6 to 12 per cent. of protein, and also a fair proportion of fat and carbohydrates, so that they had all the constituents of diet. There was also their value as an appetizer. He instituted a comparison between Stewart Island and American oysters, and also between the nutritive value of oysters and other common foods. A dozen of oysters equalled an ordinary hen's egg. He predicted that oyster-culture, as in France, would yet be a very large industry in New Zealand.

Professor Boys-Smith spoke at some length on the cooking of oysters, and stated that the less all protein food was cooked the better, provided it was made palatable. Carbohydrates were made more digestible by cooking. Oysters should be eaten as far as possible raw. She knew of only one good recipe for cooking oysters.

6. "The Maoris of the West Coast of the South Island." By H. D. Skinner.

The author explained that his paper dealt with a very small part of the subject. He mentioned first the passes to the West Coast, then some of the preparations the Maoris made for travelling across these passes, and finally indicated the discoverer of the first pass. All the greenstone we knew of in New Zealand came from one or two river-beds on the West Coast, and must have been brought across these passes. Some idea of the amount carried over might be gathered from the fact that from Murdering Beach alone about 3 cwt. of worked greenstone had been removed. The author made use of a lengthy manuscript containing the only record of the history, customs, and mythology of the Maori tribe now on the verge of extinction on the West Coast. After referring to the various passes of the Southern Alps and their significance to the Maoris, he gave a vivid description of the journeys which the Natives used to make across the Alps, and concluded with the story of Raurika, the mad woman who, about the year 1700, discovered Browning's Pass, and was the first to find a way across the great barrier.

7. "The Mammalian Heart: the Nature of its Beat, and Some Striking Variations in Rhythm recently discovered." By Dr. Stuart Moore.

Commencing with a few simple points about the anatomy of the heart, the writer went on to discuss the two theories of the causes of its action and to describe some remarkable recorded irregularities, and made the subject clear by the use of the blackboard and of several interesting diagrams shown through a magic-lantern. Incidentally, some insight was given into the remarkably ingenious methods by which physiologists can detect, record, and interpret the most delicate variations in the action of the heart.

THIRD MEETING: *4th July, 1911.*

The President, Mr. A. Bathgate, in the chair.

There was a large attendance, over two hundred members and friends being present.

Address.—Mr. R. Speight, M.A., F.G.S., of Christchurch, gave an interesting illustrated address on "Remote and Unknown Canterbury."

ABSTRACT.

The address dealt chiefly with a part of Canterbury which is little known to the general public, and lies at the head of the Rakaia, Ashburton, and Rangitata Rivers. The lecturer first of all gave a brief account of the geographical features of the area, and referred to the work of exploration carried on by Haast, Potts, and Whitcombe, as well as to the connection of Dr. Sinclair and Samuel Butler with its early history. Some account was given of the geological structure of the district and the evolution of the chief landscape-features. The lecturer drew attention to the fact that the Southern Alps in their present form are not a mountain-range of the alpine type, but rather a dissected peneplain of which the present mountain-tops are a remnant. The dissection has been brought about first of all by stream-action and then by glaciation. The effect of the latter was dealt with at greater length, and the address concluded with a description of the present glaciers at the head of the Rakaia and the adjacent river-valleys, which probably afford the finest alpine scenery in New Zealand with the exception of that in the Mount Cook district—a feature which is all the more remarkable seeing that the highest peaks in that part of the main range do not reach the height of 9,000 ft. Even this comparatively moderate elevation seems competent to deprive the wet westerly winds of by far the greater portion of the moisture they carry.

The lecture was illustrated by an extensive series of lantern-slides, giving a fine series of views of the country dealt with, and at its close a hearty vote of thanks was accorded to the lecturer on the motion of the chairman.

TECHNOLOGICAL SECTION.

Officers.—The following have been elected the executive of the section: Chairman—Mr. E. E. Stark; Vice-Chairman—Mr. M. Elliot and Mr. F. W. Furkert; Hon. Secretaries—Messrs. H. Brasch and E. C. Creagh; Committee—Professor J. Park, Messrs. E. W. Ackland, J. Lythgoe, F. W. Payne, and J. H. Scott.

First Meeting: *16th May, 1911.*

Mr. E. E. Stark in the chair.

Mr. Stark, chairman of the section, delivered an interesting address on "Alternating Currents of High Frequency," illustrated by many effective experiments. The attendance was very satisfactory for the initial meeting of the section, there being over seventy members present.

Second Meeting: *20th June, 1911.*

Present—Mr. E. E. Stark (in the chair) and a large number of members.

Address.—Mr. Frank Oakden gave a long and interesting address on "Portland Cement." The evening was found to be too short to permit of the address being brought to a close, and it was unanimously decided to continue the lecture and the discussion on it on the following Tuesday (27th June). Another large audience met on the latter date and heard the conclusion of the address.

The address dealt fully with the whole subject under the following heads: (1) Historical outline, dealing with methods of manufacture from earlier times up to the present day; (2) physical tests; (3) theories of hardening, showing the existing diversity of opinion between the highest authorities. [A full report was published in the *Otago Daily Times* of the 29th June, 1911.]

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

FIRST MEETING: *3rd May, 1911.*

Present: Mr. A. M. Wright, President, in the chair, and eighty others.

New Members.—Messrs. L. S. Jennings, W. Brock, H. R. Hogg, and J. Caughley.

A large number of donations were received and laid on the table.

Anton Dohrn Fund.—A letter was received from Dr. Benham, enclosing circulars and asking for subscriptions to the Anton Dohrn Fund. Dr. Chilton explained the reason for making the appeal, and hoped members would subscribe to such a worthy object.

Address.—Mr. R. M. Laing, the retiring President, then delivered his ex-presidential address on "A Study in Multiple Personality."

The lecturer pointed out that this address was really a continuation and development along specialized lines of an address previously given by himself to the Institute on the subject of hypnotism.

The investigation into the phenomena of multiple personality has now reached a highly technical stage. Three different types of theory have been put forward to explain these aberrations of personality and allied phenomena. These three types may be roughly classified as follows: (*a.*) The "unconscious cerebration" theory. This has been put forward in different forms by W. B. Carpenter, A. H. Pierce, and Munsterberg. According to it the automatic speech and writing of a secondary personality were no more accompanied by intelligence than the song of a gramophone. The lecturer considered this theory was quite insufficient to account for the phenomena witnessed in the more remarkable cases of alternation of personality, such as shown by Miss Beauchamp, the Rev. Thomas Hanna, and Ansell Bourne. (*b.*) The second type of hypothesis may be termed the "stratification" theory. According to it there underlies the normal consciousness one or more deeper strata of consciousness often possessed of supernormal powers. Forms of this theory may be found in the "transcendental" consciousness of Du Prel, in the "subliminal" consciousness of Myers, and the "subjective" consciousness of various popular American writers, such as Hudson. This type of theory appeared to the lecturer to be largely unsubstantiated. (*c.*) The "dissociation" theory. According to this theory certain complexes are dissociated by amnesia from the normal consciousness and lead to "automatonisms," or, when very fully developed, sometimes assume control of the bodily organism and more or less permanently play the rôle of the normal consciousness. This theory appeared to the lecturer to provide a firm foothold for the study of multiple personality and many related phenomena. Dissociation, indeed, is exhibited in sleep, dreams, hypnosis, sensory and motor automatonisms, such as crystal visions, auditory and visual hallucinations, automatic speech and writing, the phenomena of revivals, conversion, demoniacal possession, spirit-control, and many cases of insanity. Thus a naturalistic explanation was obtained of many phenomena usually termed occult. However, after full scope had been given to explanation by dissociation, there still remained a residuum of unexplained phenomena, which might for the present at least be regarded as "supernormal."

The body of the address consisted of a detailed description of the above phenomena as exhibited by Miss Christine Beauchamp and described by Dr. Morton Prince. With infinite patience Dr. Morton Prince was able to synthesize the disintegrated memories of Miss Beauchamp and restore her to normal health. Under ordinary circumstances her neurasthenic and psychasthenic condition would inevitably lead to her confinement in a mental hospital, but Dr. Prince by his close investigation of the case and his treatment of it by therapeutic suggestion was able to control the various personalities developed and bring out renewed mental equilibrium.

SECOND MEETING: *7th June, 1911.*

Present: Mr. A. M. Wright, President, in the chair, and nearly one hundred others, including the officers of the s.s. "Terra Nova," and Captain Bollons of the G.s.s. "Hinemoa."

New Members.—Messrs. W. W. Garton, Richard Finch, T. Fletcher, G. D. Hansford, W. D. Kirkpatrick, B. Seth Smith, C. Foweraker, I. E. Newton, M.A., G. Whitehead, B.A., H. D. Acland.

Address.—"The Natural History of Whales." By D. G. Lillie, B.A., Biologist to the Antarctic Expedition.

The lecturer first gave a brief outline of the phylogenetic development of the various orders of the mammalia, with special reference to the whales, and detailed the chief differences between these animals and fishes. He showed the relationship between the whales and the mammals most closely connected with them, specially mentioning the modification of the various organs to suit a marine environment. He noted that the grooves which appear in the skin of the rorquals probably function in respiration. The lecturer concluded with an account of the classification of whales and of their habits. The address was illustrated with an extensive and excellent series of drawings.

In moving a hearty vote of thanks to the lecturer Mr. Edgar R. Waite referred to the original work which had already been done by Mr. Lillie in connection with whales, a subject of investigation of the greatest difficulty.

In acknowledging the vote of thanks, Mr. Lillie gave some brief indications as to how the different species of whales could be determined by any one seeing them from the deck of a ship, but said that it was very difficult indeed to come to a correct conclusion without long experience.

THIRD MEETING: *12th July, 1911.*

Present: Mr. A. M. Wright, President, in the chair, and forty others.

New Members.—Messrs. W. Goss, J. Deans, and W. C. Colee.

Address.—"Recent Advances in Radioactivity." By D. C. H. Florance, M.A., M.Sc.

The lecturer gave a very clear and interesting account of the methods adopted during the last two years for investigating the phenomena of radioactivity, and illustrated his remarks with exhibits and experiments. He paid special attention to the series of products derived from uranium, and the behaviour of atoms under the influence of the α, β, and γ rays. At the close he was accorded a very hearty vote of thanks.

Papers. — 1. "The Action of Alkyl Iodides on Copper-oxide." By H. G. Denham, M.A., D.Sc., Ph.D. (See page 29.)

2. "Note on the Species of *Hydra* found in New Zealand." By G. Archey; communicated by Dr. Chilton. (See page 25.)

3. "Additions to the Fish Fauna of the Kermadec Islands." By Edgar R. Waite, F.L.S. (See page 28.)

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

First Meeting: *2nd June, 1911.*

The President, Mr. H. Hill, B.A., F.G.S., in the chair.

New Member.—Mr. Alexander.

Address.—The President delivered his presidential address on "Individualism *versus* Collective Industrialism."

Mr. Hill first referred to the advantage of being a member of the Institute, and urged the desirability of keeping records of early settlement, of the natural characters of the country, of original and introduced flora and fauna, of climate, of temperature, of rainfall, of floods, &c.

The address dealt with the economic relations between workers and masters and the State. The comparison between the State and a person was made with respect to the various changes taking place as time passed, and deductions were made therefrom. Some scenes in industrial centres in England which were visited by the lecturer were described, and the evil effects of specialization were noted. The treatment of the "human machine" was discussed, and the question raised why the employer did not treat the worker as well as the inanimate machine. The State should help workers in sickness, unemployment, and old age by better methods than it does, and national provision should be made for such cases. As the State looks after children in providing education for their future trades and professions, so also it should make provision that during their later life they should never be dependent upon mere charity. Germany has provided a scheme for her workers, and New Zealand has instituted pensions and a National Provident Fund. More is required.

Second Meeting: *30th June, 1911.*

The President, Mr. Hill, B.A., F.G.S., in the chair.

New Member.—Mr. Malcolm McLeod.

Papers.—1. "Some Contents of Napier Waters." By J. Niven.

A later paper will deal more fully with the subject.

2. "A Chat on Some Peculiar Stones." By H. Hill, B.A., F.G.S.

Various peculiar and interesting stones were shown and their story told.

PAPERS.

1. *Some Effects of Imported Animals on the Indigenous Vegetation.*

By B. C. Aston, F.I.C., F.C.S.

[*Read before the Wellington Philosophical Society, 10th May, 1911.*]

The Tauherinikau Valley is portion of a public-works reserve, and extends from the mouth of the gorge near Featherston for some twelve miles in a northerly direction. The valley is a natural fastness into which man seldom penetrates. Bounded on all sides by mountains of 1,500 ft. or more in height, the only outlet for the river being a trackless gorge, the valley has become a sanctuary for escaped cattle, wild pigs, and rabbits. On either side of the river, which is comparable with the Hutt in size, are extensive gravel-flats covered with light scrub, chiefly *Leptospermum* (manuka), frequently broken by patches of good grass land on which Yorkshire fog, red and white clovers, and cocksfoot afford excellent pasturage for cattle. In January, 1910, one herd of eleven, which allowed one to approach closely, was seen. Along the narrower and higher portions of the valley, where the forest closes into the stream, tracks have been made by the cattle in all directions. It is probably from this valley that they have gained access to the Mount Alpha portion of the Tararua Range above the bush-line. On this high country the effect of the cattle is most readily observed. Well-beaten tracks have been made along all the main ridges from the Quoin (3,900 ft.) to Mount Alpha (4,600 ft.), and thence to the south side of Mount Hector, approaching almost to the summit. No tracks were observed on the Otaki side of Mount Hector. On the slopes of Mount Alpha nearly every plant of *Ligusticum dissectum* T. K.* had been closely cropped, from which it appears that this succulent umbellifer, which is one of the most abundant and characteristic plants of this range, will disappear where the cattle are able to reach it. No good argument can be adduced for allowing the cattle to remain. Being so tame they will not provide sport; of the Hereford breed, they are not so picturesque as, for instance, Highland cattle would be; and, although as track-makers they have done some good work, further toleration of their existence is likely to result in a permanent alteration of the flora, which, from the proximity to Wellington City, should be preserved intact. The effect of the depredations of pigs is everywhere noticeable in the valley, both in the forest and on the manuka flats and grass lands, where in the aggregate large areas have been turned over. On the valley-flats a fine patch of the rare orchid *Gastrodia sesamoides* had been destroyed. *Gastrodia Cunninghamii*, with its large underground tubers, now fairly common in the Tararua forests, is likely to become very rare. On the high bushed spurs, where well-defined tracks have been worn, the most noticeable objects of the attentions of pigs are the species of *Panax* (family *Araliaceae*). These shrubs (*P. Colensoi*, *P. arboreum*, and *P. simplex*) are often barked up to 3 ft. or 4 ft. from the ground, the white wood beneath showing the imprint of large teeth. In the Marlborough Sounds goats are

* High up on Ngauruhoe rabbits are similarly exterminating *L. aromaticum*.

fast killing out the species of *Panax*, which are completely barked up to 4 ft. or 5 ft. from the ground. Horses will also bark the shrubs of this genus.

The Waipakihi River (the main source of Lake Taupo and the Waikato River) rises in the Kaimanawa Mountains, and flows through them for some eighteen miles before emerging into the plain. The upper reaches drain some thousands of acres of pumice-flats, the Kaimanawa Range, although of old sedimentary formation, having been plentifully peppered with pumice from the contiguous volcanic area. The pumice-flats contain material in which rabbits may easily burrow, and they have accordingly taken possession in their thousands. The flats are at an elevation of from 3,000 ft. to 3,500 ft., and are covered with a shrubby growth of *Veronica buxifolia*, *V. laevis*, *V. tetragona*, and *V. salicifolia* (family *Scrophulariaceae*), or with tussocks of *Poa caespitosa* and *Festuca rubra* and *Danthonia Raoulii* (family *Gramineae*), with smaller plants between, such as *Raoulia australis*, *Acaena* sp., &c., and *Aciphylla Colensoi*. It is difficult, owing to the ravages of the rabbits, to say what the flora of the grass-flats originally was. Probably a number of finer grasses have been eaten out, and evidence is not wanting that food is scarce. Little piles of the leaves of *Veronica salicifolia* were seen near the bushes, which may be attributed to rabbits nibbling the stalks off and leaving the blade. Many plants of *Aciphylla Colensoi* (family *Umbelliferae*) had been eaten down to the heart. The harsh *Festuca rubra* tussocks seemed to have suffered less than other grasses, but even these had been occasionally attacked. At Waipahi (Kaimanawas), just above the bush-line at 4,400 ft., on the hillside, *Danthonia Raoulii* was the sole survivor, and that had been badly eaten, possibly by wild horses as well as by rabbits and pigs.

These two valleys, though widely separated, are excellent examples of natural sanctuaries, including extensive river-flats walled in by steep, heavily bushed mountains, the only natural outlet being a long, winding gorge where the river issues into the plain. The floras of these valleys are rapidly changing in character owing to the attacks of imported animals, which, because of difficulty or illegality of access to the valleys, are not kept in check by man.

One effect of imported animals may be to restrict the more edible plants to situations beyond their reach. A species, therefore, which is able to adapt itself to any station may by compulsion be restricted to one. For instance, *Lepidium oleraceum* ("Cook's scurvy-grass"—family *Cruciferae*) has been eaten out along the Wellington Coast, and is now generally only to be found growing on inaccessible rock-faces. Similarly, *Senecio Greyii* (family *Compositae*), although able to grow on any soil, as testified by its presence in most collections of native shrubs, at Mukumuku, Palliser Bay, is restricted, possibly chiefly owing to goats, to stations which would lead the ecologist to class it as a chasmophyte. One may see abundance of this beautiful free-flowering plant growing on the cliffs, but it is with great difficulty that specimens may be secured. A common plant of littoral rock-faces is the grass *Agropyrum scabrum*, which is greatly relished by sheep. It is being eaten out possibly on the central volcanic plateau of the North Island and elsewhere. At Alexandra, Central Otago, this grass assumes the habit of a tussock-grass, and is then better able to resist close cropping.

It is, indeed, on the littoral that the evidences of the destructive influence of animals on vegetation are most readily found. The long winding coast-line of South Wellington Province affords a commonage where both domestic

and wild animals may resort for salt-licks and saline plants, such as *Salicornia australis* and other plants of the salt-bush family (*Chenopodiaceae*). When food is scarce the giant perennial-stemmed grass *Spinifex hirsutus* is voraciously eaten, as has been observed at Pencarrow Heads and Titahi Bay. At the latter habitat marram-grass (*Ammophila arundinacea*) was untouched, but horses had eaten the *Spinifex* off short. The preference which stock exhibit for *Spinifex* over marram should be taken into account in considering the rival merits of the two grasses as sand-binders. A fern, *Gymnogramme*, once abundant on Wellington coasts, is believed to have been exterminated by sheep and rabbits. Being an annual it would be eaten before the spores were shed.

At Rocky Bay (Titahi Bay) is a recently raised beach. High above high-water mark is a boulder beach, then a sandy strip containing fresh-water pools, the sand being covered with a closely cropped sward of (1) *Crantzia lineata* (family *Umbelliferae*), (2) *Samolus repens** (family *Primulaceae*). (3) *Ranunculus acaulis*, named in the order of their relative abundance. There are also present *Atropis stricta* (family *Gramineae*), *Cotula coronopifolia* (family *Compositae*), and *Selliera radicans* (family *Goodenovieae*). Sheep greedily browse on this sward and drink from the pools, in which frogs are living. The term "salt meadow," which is applied by ecologists to this formation, must therefore not be interpreted in a superlative sense. Separating the salt meadow from the sea is a raised rocky terrace. Sheep have been observed browsing on a sward of similar composition near Island Bay. On the dry hillside above Rocky Bay *Eryngium vesiculosum* (family *Umbelliferae*) has been closely eaten down by sheep, and it is feared that *Lepidium tenuicaule* var. *minor* (family *Cruciferae*), common here in 1907, has been entirely eaten out. On the rocky scarps near here *Aciphylla squarrosa* was observed in March, 1908, to have been badly eaten back. Further round the Titahi Bay peninsula, at the point facing Plimmerton, are stretches of raised sandy beach containing the remains of sea-animals and consequently much carbonate of lime. This has resulted in a shallow black soil supporting a sweet herbage, largely the naturalized alfilaria (*Erodium circutarium*, family *Geraniaceae*). The rabbits are spoiling much of this by covering it with earth from their burrows.

Changes in the indigenous flora by means of the spread of exotic species, the seed of which is distributed by imported animals, are being brought about in various localities. Examples which might no doubt be added to are the African box-thorn (*Lycium horridum*), which is spreading in the Taranaki bush; the blackberry (*Rubus fruticosus*), in many parts of the North Island and in the Nelson Province; the elderberry (*Sambucus niger*), near Dunedin; the gooseberry (*Ribes grossularia*), in many parts of the South Island; the Cape gooseberry (*Physalis peruviana*), in the Wanganui, Thames, and Tauranga districts; the ink-plant (*Phytolacca octandra*); and even the strawberry (*Fragaria vesca*), in some parts of the Auckland Province. All these fruits are spread by birds, especially the blackbird, and thereby the native vegetation certainly is being displaced.†

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* At Havelock (Marlborough) the estuarial mud-flats are covered with *Samolus*, and the cattle laboriously drag themselves through the mud to obtain the plant.

† The spread of introduced weeds is not without its economical side. Sheep have been fattened on fleabane (*Erigeron strigosa*) in North Auckland and on *Atriplex patula* var. *hastata* in Canterbury, while the winged or star thistle (*Carduus pycnocephalus*) is, according to Dr. Petrie, the salvation of the runholder in parts of Central Otago.

Rats (both the grey and the black), by eating the seeds, undoubtedly influence the spread of many species. The grey rat has a fondness for the seeds of the New Zealand passion-flower (*Passiflora tetrandra*), the fruit of the kiekie (*Freycinetia Banksii*), and nikau-palm (*Rhopalostylis sapida*). Possibly the introduced birds may assist in the spread of the indigenous plants having edible fruits, such as the wineberry (*Aristotelia racemosa*), *Fuchsia excorticata*, poroporo (*Solanum aviculare*), and bramble (*Rubus australis*).

No one who has seen sheep covered with *Acaena* "burrs" (piripiri) can hesitate to admit the large part which that animal plays in the spread of this native weed.

Pigs are most partial to the seed of the hinau (*Elaeocarpus dentatus*, family *Tiliaceae*), on which they fatten, and the roots of bracken (*Pteris aquilina*). The native arrowroot fern (*Marattia fraxinea*) is fast being killed out by pigs on account of its large starchy rhizome.

The spread of clovers and other leguminous seed by animals must be a considerable factor in altering vegetation. At Palliser Bay gravel-fans, covering in some cases many acres, are formed by heavy rainfalls. The first plant to establish itself on the finer detritus is *Raoulia australis*, forming large depressed patches. Ultimately a certain amount of organic matter is formed by these patches of vegetation, and in October, 1907, clovers and other introduced leguminous plants were noted to be growing out of these patches. It is possible that they may in time displace the *Raoulia*, as in older but similarly formed land in the vicinity a close sward of *Leguminosae* monopolizes the soil.

The partiality which stock exhibit for certain shrubs such as the mahoe or hinahina, the so-called "cow-tree" of the settler (*Melicytus ramiflorus*, family *Violaceae*), the karamu (*Coprosma grandifolia* and *C. tenuifolia*, family *Rubiaceae*), and the broadleaf (*Griselinia littoralis*, family *Cornaceae*) have led to the practice among stockmen of cutting the shrubs down for fodder in times of scarcity. Another shrub evidently much relished is the mangrove (*Avicennia officinalis*, family *Verbenaceae*). Travellers along the Thames railway-line may see the lower branches of the fine mangrove shrubs of the estuaries trimmed off by cattle in the same way as they do the weeping willows in the meadows, no branches appearing below a certain level—the limit of the cattle's reach. In the Rotorua district I am informed that tawa (*Beilschmiedia tawa*, family *Lauraceae*) leaves are readily eaten by stock. Cattle greedily eat karaka-leaves (*Corynocarpus laevigata*, family *Anacardiaceae*). The fruit, poisonous to some animals, causes in pigs only a partial paralysis of the hind legs.

Central Otago, which contains such excellent examples of the effects of overstocking and of the rabbits on the indigenous vegetation, has furnished me with a few notes. On the Rock and Pillar Range (Middlemarch side) in December, 1908, *Hymenanthera crassifolia** (family *Violaceae*) was found to be eaten down by rabbits. (This effect has also been largely observed on the raised beaches at Turakirae Head, Palliser Bay.) *Celmisia Lyallii* (family *Compositae*) was almost eaten out except on a few inaccessible rocks at 3,700 ft. At Gimmerburn, on a dry hillside above the Government nursery, the ground was bare save for a few scattered plants of *Agropyrum pectinatum* (naturalized) and *Koeleria Kurtzii*. These two grasses had been nibbled down very short, but were surviving, and the former was producing seed in quantity.

* Mr. Cheeseman thinks this may be *H. dentata* var *alpina*.

The soils of the Southern Islands are the very antithesis of those of Central Otago, but even here the flora is being slowly changed by imported animals. On Auckland Island, in November, 1907, at Flat-topped Mountain, Carnley Harbour, and above the scrub-line, pigs had eaten freely of *Pleurophyllum Hookeri* (family *Compositae*), having grubbed up the plant to get at the rootstock. At Port Ross, Auckland Island, in January, 1909, at 1,100 ft. numerous pig-tracks were observed, and *Pleurophyllum speciosum* appeared to have been eaten out on all stations but inaccessible rock-faces. At Enderby Island the cattle had considerably cut up the bush, but their greatest effect was noticeable on the tussocks of *Poa littorosa*, a grass which is evidently being exterminated at that habitat. At Campbell Island, which is inhabited and farmed as a sheep-run, the *Stilbocarpa polaris* (family *Araliaceae*) is being eaten out by sheep. On the other hand, there are no pigs, as at Auckland Island, to attack the *Bulbinella Rossii** (family *Liliaceae*), which is spreading at an alarming rate. On the "burn," under the "Judge's Chair," at 725 ft. the *Dracophyllum scoparium* and *D. longifolium* are being replaced by *Poa littorosa* and *Bulbinella Rossii*. In one paddock near the wool-shed at Perseverance Harbour the flora consisted solely of a thick mass of *Bulbinella Rossii*—a magnificent sight.

The important family *Leguminosae* is sparsely represented in New Zealand. Horses are fond of chewing the taller species of *Carmichaelia*. It would be interesting to learn whether the dwarf species are diminishing owing to the attacks of rabbits in the more arid parts.

Sheep, and to a less degree cattle, frequently eat the smaller species of tutu (*Coriaria*, family *Coriariacae*), though it is not likely that they appreciably affect its abundance. Fern (*Pteris aquilina*, family *Filices*) is kept in check by close feeding by cattle. Both of these are instances of plants which under certain conditions may have a poisonous effect on stock, serving as part of a regular ration. The hinahina (*Melicytus ramiflorus*) has been suspected of injuriously affecting stock at Catlin's (Otago), but definite information is wanting.

Cattle and sheep, though having their preferences, will eat most ferns, any shrubs, and seedlings of forest-trees when food is scarce. In small isolated clumps of bush the undergrowth is sometimes completely destroyed.

Omitting the grasses, the native plants which find most favour with herbiverous animals would appear to be those belonging to the families *Cruciferae*, *Umbelliferae*, *Araliaceae*, *Violaceae*, *Malvaceae*, *Tiliaceae*, *Rubiaceae*, *Primulaceae*, *Leguminosae*, and *Chenopodiaceae; Juncaceae* and *Cyperaceae* contain genera (*Juncus*, *Luzula*, and *Mariscus*) species of which are often devoured by stock; *Compositae* and *Liliaceae* contain some species which are often browsed.

There are doubtless other non-poisonous native plants which supply either normally or in times of scarcity food for animals, and the author would be extremely obliged if other observers would publish or communicate to him any facts which will throw further light on the subject.

Very little has been recorded in the past on the subject of this paper. An interesting article on "The Displacement of Species in New Zealand," by the late T. Kirk (Trans. N.Z. Inst., vol. 28, p. 17) gives a general account of the naturalization of many forms of life and the probable effect on the indigenous forms. Of special interest under the title of this paper are the

* Although the *Bulbinella* does not seem to be relished by sheep or cattle, the allied liliaceous plants *Phormium* and *Cordyline* are eaten on the mainland by cattle.

facts that rats attack the *Gastrodia* tuber, that birds apparently spread the tutsan (*Hypericum Androsoenum*) seeds, and that the tainui (*Pomaderris apetala*) has been completely destroyed at Kawhia, where it was formerly abundant. Dr. L. Cockayne, J. S. Tennant, and E. R. Waite ("Subantarctic Islands of New Zealand," pp. 235, 599) also have some remarks on the effect of pigs on Auckland and of sheep on Campbell Island floras. (See also Dr. L. Cockayne in Trans. N.Z. Inst., vol. 36, p. 297.)

Mr. Cheeseman ("Manual of the New Zealand Flora," pp. 81, 82, 223) mentions that *Hibiscus diversifolius* (family *Malvaceae*) is being destroyed rapidly by cattle, fires, &c.; that *Entelea arborescens* (family *Tiliaceae*)* is greedily eaten by cattle and horses, and is consequently becoming rare on the mainland, except in comparatively inaccessible situations; and that *Angelica gingidium* has become scarce owing to the attacks of stock.

I am indebted to Messrs. T. F. Cheeseman, D. Petrie, E. Phillips Turner, F. R. Field, and A. Morris Jones for much information contained in this paper.

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2. *Note on* Helichrysum fasciculatum *Buchanan.*

By T. F. Cheeseman, F.L.S.

In the "Transactions of the New Zealand Institute," vol. 9, p. 529, Mr. J. Buchanan described, under the name of *Helichrysum fasciculatum*, a plant collected on the Tararua Mountains by Mr. H. H. Travers. When preparing my "Manual of the New Zealand Flora," Mr. Buchanan's types of that particular species were not accessible to me, and the only specimen available for examination was in such poor condition that no positive conclusions could be arrived at. Under such circumstances, I had to rely principally on Mr. Buchanan's description and figure, which seemed to show that the species was distinct.

During a recent visit to the Dominion Museum I had an opportunity of inspecting Mr. Buchanan's original specimens, and was at once impressed with their resemblance to *Raoulia grandiflora*. Since then Mr. Hamilton has been kind enough to lend them to me for leisurely examination, the result of which I submit herewith. In the first place, an examination of the flowers proves that the plant cannot be referred to *Helichrysum*, as that genus is understood at the present time. *Helichrysum*, in addition to its numerous hermaphrodite florets (a character which distinguishes it from *Gnaphalium*, in which the female florets outnumber the hermaphrodite), possesses slender pappus-hairs, which are scabrid or pectinate at the base, and the achenes are either glabrous or simply puberulous. Now, in Mr. Buchanan's plant the hermaphrodite florets certainly outnumber the females, but the pappus-hairs are stout, rigid, compressed, thickened and toothed above, but quite naked at the base, and the achenes are hirsute with long hairs. These characters of the pappus and achenes are not only at variance with the definition of *Helichrysum*, but agree perfectly with that of the section *Imbricaria* of the genus *Raoulia*, to which *R. grandiflora* belongs.

Comparing *H. fasciculatum* with *R. grandiflora*, they appear almost identical, one important difference being alone noticeable: *R. grandiflora* invariably has its flower-heads solitary and terminal. I have gathered

* Stock are also partial to the allied wineberry (*Aristotelia racemosa*).

it in many localities in both Islands, and examined hundreds of specimens, but I have never seen even two flower-heads to a stem, and I understand that the experience of other observers is the same. On the other hand, Mr. Buchanan's two flowering specimens of *H. fasciculatum* each have three flower-heads. If this character should prove constant, it is quite sufficient to uphold the specific distinction of his plant, but until additional specimens with the same peculiarity have been obtained it is permissible to take the view that we are dealing with a pair of abnormal specimens. In support of this view I may mention that the individual heads are precisely similar to those of *R. grandiflora*, the shape and size of the corolla, the pappus-hairs, and the achenes being identical in both. The leaves of *H. fasciculatum* are slightly larger and broader than in *R. grandiflora*, and the covering of felted tomentum somewhat denser, but these differences are not more than might be expected in an unusually luxuriant form. On the whole, I am inclined to regard it as an aberrant form of *R. grandiflora* rather than a distinct species.

Both Sir J. D. Hooker and myself have expressed the opinion that the remarkable differences between the pappus-hairs of the two sections of the genus *Raoulia* would ultimately, when the gnaphalioid *Compositae* were fully worked out, prove sufficient to separate them as distinct genera. In a series of papers contributed to the Botanical Society of Geneva, under the title of "Contributions à l'Etude des Composées," Dr. Gustave Beauverd, the well-known keeper of the Boissier Herbarium, has endeavoured to clear up some of the difficulties which at present encumber the classification of the *Gnaphalieae*. In a special number of the series he discusses the relationships of *Raoulia* with its allies, and establishes three new genera—*Psychrophyton*, consisting of Hooker's section *Imbricaria* of *Raoulia; Leucogenes*, containing *Helichrysum Leontopodium* and *H. grandiceps;* and *Ewartia*, comprising three species from Victoria and Tasmania, of which *R. catipes* is the type. Dr. Beauverd's paper, which is printed in the Bulletin of the society for 1910 (pp. 207 to 241), is one of the most important publications dealing with the New Zealand *Compositae* that has appeared for many years, and I hope to prepare a *résumé* of it for publication in the Transactions.

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3. *Note on the Species of* Hydra *found in New Zealand.*

By Gilbert Archey.

Communicated by Dr. Chas. Chilton.

[*Read before the Philosophical Institute of Canterbury, 12th July, 1911.*]

Very little appears to have been published on the species of *Hydra* found in New Zealand. The first definite record was made in 1867 by Dr. Coughtrey,* who found a specimen in a stream near Dunedin. In his note he says, "This *Hydra*, in general form, is like *H. viridis*, in colour pale brown, and has seven tentacula, which are peculiar in this respect, that they are distinctly annulated and each ring is fringed." No name was given to this species by Coughtrey. In an earlier paper he says in a footnote, "I have seen two *Hydrae* in New Zealand, one nearly like *H. viridis* of Britain, and the

* Coughtrey: "Critical Notes on New Zealand *Hydroida*." Ann. Mag. Nat. Hist., ser. 4, vol. 17, p. 22; 1867.

other I have not been able to identify with the British members of *Gymnochroa.*"*

In 1879 Mr. A. Hamilton,† in a paper on fresh-water *Polyzoa*, incidentally mentioned the occurrence in a swamp near Napier of "a large reddish-brown *Hydra.*" The next record is by Farquhar,‡ who, in 1896, published a catalogued list of the New Zealand *Hydroida.* In his list he mentions only one *Hydra—i.e.*, the one which Coughtrey had described as above. Unfortunately, he calls it *H. viridis*, evidently misreading Coughtrey's description. Under this name it appears in the "Index Faunae Novae-Zealandiae."§

In 1910 Dr. W. B. Benham‖ published a note on "A Species of *Hydra* new to New Zealand," which was found in the Shag Valley, and which, he said, was characterized by a rich reddish-brown, almost mahogany, colour, and by the great size (up to 15 mm.). He also refers to a small brown species found near Dunedin, probably the same as the one mentioned by Coughtrey.

In addition to the published facts referred to above, Dr. Hilgendorf, Professor Thomas, Professor Kirk, and Dr. Chilton have kindly contributed information as to the occurrence of species of *Hydra* in New Zealand.

Dr. Hilgendorf has seen a small brown form which occurs in ponds at Woodhaugh, near Dunedin. This is probably the same as the brown species of Coughtrey and Benham.

Professor Kirk writes that there appear to be two kinds in Wellington, one a dark-brown form, and the other a light-brown one. Professor Thomas says that *Hydra* appears to be widely distributed about Auckland, and notes the occurrence of the following: (1) a brownish or yellowish-brown form; (2) a form of a colour to suggest orange; (3) a nearly colourless form; (4) a green species. He considers (1) to be the form commonly called *H. fusca*, and (2) and (3) to be colour-varieties of it. The forms noted by Professor Kirk and Dr. Hilgendorf probably belong to this species also.

In 1885 Dr. Chilton in his manuscript note-book recorded the appearance of a *Hydra* in Christchurch. The animal observed was light brown in colour, and appeared to him to be the same as the form commonly known as *H. fusca.*

Specimens of a brown *Hydra* have, for several years past, been obtained in moderate numbers from the River Avon, for use in the biological laboratory at Canterbury College, though until lately no green ones were seen. But in April of this year, while searching for *Hydra* in water from the River Avon, several green specimens were discovered. These forms agree exactly, in the characters that can be observed, with the descriptions given of *H. viridis.* The gonads, however, have not been seen.

According to Hickson,¶ three species of *Hydra* are known in England —viz., *H. viridis* Linn., *H. oligactis* Pall. (= *H. fusca* Linn.), *H. vulgaris* Pall. Hickson gives a short description of each of these species.

A comparison of the forms found in New Zealand with these and other descriptions shows that the green species observed in Christchurch is certainly *H. viridis*, and the green form noted by Professor Thomas at Auckland probably must be placed here also. It seems likely that the Shag Valley

* Trans. N.Z. Inst., vol. 8, p. 299; 1876.

† Hamilton: "On *Melicerta ringens* and *Plumatella repens.*" Trans. N.Z. Inst., vol. 12, p. 303.

‡ Farquhar: Trans. N.Z. Inst., vol. 28, p. 468; 1896.

§ "Index Faunae Novae-Zealandiae," edited by F. W. Hutton, London; 1904.

‖ Benham: Proc. N.Z. Inst. for 1909, part iv, p. 128; 1910.

¶ Hickson: "Cambridge Natural History," vol. I, *Coelenterata*, p. 256; 1906.

specimens described by Dr. Benham are representatives of *H. vulgaris*, though this cannot be decided with certainty till they have been examined more closely. The large reddish-brown form noted by Hamilton will probably also belong to this species. The light-brown species mentioned above as found at Dunedin, Christchurch, &c., appears to belong to the well-known brown *Hydra* of Europe, commonly referred to as *H. fusca*. This should, however, be called *H. oligactis*, this being the name first given to the species by Pallas. It seems to be the most common species in New Zealand, having been seen in Christchurch, Wellington, Auckland, and Dunedin. Coughtrey's species evidently belongs here too.

The New Zealand species now known of *Hydra*, then, are *H. viridis*, *H. vulgaris*, and *H. oligactis*.

Hydra viridis Linn.

Hydra viridis Linn., Sys. Nat., 12th ed., p. 1320, 1767; Johnston, British Zoophytes, p. 121, 1847; Hincks, British Hydroid Zoophytes, p. 312, 1868; Hickson, Camb. Nat. Hist., vol. 1, p. 256, 1906; Brauer, Zool. Anz., vol. 33, p. 790, 1909.

Dr. Brauer says that the correct name for this species should be *H. viridissima* Pall. (1766), but the name *H. viridis* is so well known and commonly accepted that it would be inconvenient to alter it; and, moreover, it was used by Linnaeus for this form in the 10th edition of the Systema Naturae, though not definitely as a specific name. In this edition Linnaeus gave all the forms of *Hydra* under the one name, *H. polypus*, and it was not until the 12th edition that he divided them up into separate species.

Hickson describes this species thus: "Colour grass-green. Average number of tentacles, eight. Tentacles shorter than the body. Embryonic chitinous membrane spherical and almost smooth."

The specimens from the River Avon agree closely with the descriptions given by Hickson, Johnston, and Hincks. The species is now known in New Zealand from Christchurch and Auckland.

? *Hydra vulgaris* Pallas.

? *Hydra vulgaris* Pallas, Elench. Zooph., p. 30, 1766; Hickson, Camb. Nat. Hist., vol. 1, p. 256, 1906. *Hydra* ("reddish-brown species"), Hamilton, Trans. N.Z. Inst., vol. 12, p. 303, 1879; Benham, Proc. N.Z. Inst., 1909, p. 128, 1910.

Hickson's description is as follows: "Colour orange-brown. Tentacles rather longer than the body, average number six. Embryonic chitinous membrane spherical and covered with numerous branched spines." Brauer adds that the proximal end of the body is not narrowed into a stalk, that four kinds of thread-cells are present, and that the animal is hermaphrodite.

Habitat.—Shag Valley, Dunedin; Petane Valley, Napier.

I have not seen specimens of this species.

Hydra oligactis Pallas.

Hydra oligactis Pallas, Elench. Zooph., p. 29, 1766; Johnston, British Zoophytes, p. 124, 1847; Hincks, British Hydroid Zoophytes, p. 315, 1868; Hickson, Camb. Nat. Hist., vol. 1, p. 256, 1906; W. M. Sale, Cat. Austral. Hyd. Zooph., p. 187, 1884; Brauer, Zool. Anz., vol. 33, p. 792, 1909; *H. fusca* Linnaeus, Sys. Nat., 12th ed., p. 1320, 1767; *H. viridis* Farquhar, Trans. N.Z. Inst., vol. 18, p. 468, 1886; Hutton, Index Faunae N.Z., p. 321, 1904.

"Colour brown. Tentacles capable of great extension, sometimes when fully expanded, several times the length of the body. Average number, six. Embryonic chitinous membrane plano-convex, its convex side only covered with spines."—(Hickson.)

Habitat.—Christchurch, Wellington, Auckland, and Dunedin.

In the paper by Dr. Brauer referred to above *H. oligactis* is divided into two species—viz., *H. oligactis* Pall. and *H. polypus* Linn. The defining characters given by him are,—

"*H. oligactis* Pall. Stalked, tentacles very long. Body 2–3 cm. long. Three kinds of thread-cells, sexes separate, testes on all parts of the body except the stalk. Eggs usually adhering in groups, spherical, and covered with very short spines. Colour grey, brown, or red."

"*H. polypus* Linn. Stalked, body not more than 2 cm. long, usually 1–1·5 cm. Four kinds of thread-cells. Hermaphrodite, testes only in distal third of body, eggs attached singly with under-surface smooth, upper convex and covered with short spines. Colour grey or brown."

The brown forms I have examined seem to belong to *H. oligactis*. Only three kinds of thread-cells can be made out, the three kinds apparently corresponding to those described by Brauer as occurring in *H. oligactis*. It has not been possible, however, to examine the gonads in these forms, and until this is done their identity must remain to a certain extent doubtful.

Of the specimens found near Melbourne, Mr. W. M. Sale observes that "the attenuation of the lower part of the body is by no means so conspicuous as shown in Mr. Hinck's figures of the English species." This, too, is the case with most of the specimens of H. *oligactis* seen in Christchurch.

It is to be noted that all the specimens of *Hydra* in New Zealand seem to have been found near habitations. I have not heard of any having been found in spots where the possibility of introduction by man could be excluded. The consideration of this, and the fact that the New Zealand species are apparently the same as those found in Europe, seem to lead to the conclusion that *Hydra* is not indigenous to New Zealand, but has at some time or other been accidentally introduced.

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4. *Additions to the Fish Fauna of the Kermadec Islands.*

By Edgar R. Waite, F.L.S., Curator, Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 12th July, 1911.*]

In consequence of the destruction of his farm at the Kermadec Islands by the recent hurricane, Mr. Roy C. Bell returned with his family to New Zealand. He brought with him a small collection of fishes, in continuation of the endeavours of Mr. W. R. B. Oliver, who, as a member of the party which visited the islands in 1908, supplied the material already recorded.* The specimens were, for the most part, picked up dry upon the beach or gathered from rock-pools on Sunday Island. Owing to mutilation many of them are irrecognizable, and those which can be identified are known species. The following have not been previously recorded from the Kermadec Islands :—

* Waite: Trans. N.Z. Inst., vol. 42, 1910, pp. 370–383, pl. xxxv and xxxvi.

Euleptorhamphus longirostris Cuvier, Règne Anim., 2nd ed., vol. 2, p. 286, 1829.

The only specimen contained in the collection measures 336 mm. from the tip of the upper jaw to the end of the middle rays of the caudal, and the mandible projects 120 mm. beyond the upper jaw. I have previously recorded this species for Lord Howe Island.*

Aulacocephalus temmincki Bleeker, Verh. Batav. Gen., vol. 26, 1857, Ichth. Jap., p. 12.

This record appears to be the first for the species in the Western Hemisphere, and the locality represents its most southerly known range. The places whence it has been obtained are widely separated, and are as follows : Japan, Siam, Mauritius, Kermadec Islands. The specimen measures 270 mm. in length.

Epinephelus daemelii Günther, Ann. Mag. Nat. Hist. (4), vol. 17, p. 391, 1876.

Quite common on the coast of New South Wales, and found also at Lord Howe and Norfolk Islands, this species is now recorded for the Kermadec Islands, and furnishes another instance of the similarity of their respective fish faunas, a matter to which I have already drawn attention.

Upeneus signatus Günther, Ann. Mag. Nat. Hist. (3), vol. 20, p. 59, 1867.

A similar example is provided by the red mullet, known from the waters of New South Wales and Lord Howe Island. Though not yet taken at Norfolk Island, it is tolerably certain to be found there when representative collections of its fauna are made.

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5. *The Action of Alkyl Iodides on Copper-oxide.*

By H. G. Denham, M.A., D.Sc., Ph.D.

[*Read before the Philosophical Institute of Canterbury, 12th July, 1911.*]

The existence of cupric iodide in aqueous solution was first demonstrated by Moritz Trautz (Ber. d. D. Chem. Gessell, 1884, vol. 17, 1866), while Carnegie (Chem. News, 1889, vol. 59, 57) showed that any attempt to obtain solid cupric iodide by the evaporation of a solution containing Cu^{++} and I^- ions always led to the separation of iodine and cuprous iodide. Walker and Dover (Jour. Chem. Soc., 1905, vol. 87, 1584) obtained a compound of the formula CuI_4, but all efforts to obtain cupric iodide itself have up to the present proved futile. The presence of the slightest trace of moisture is sufficient to cause the decomposition of the unstable cupric iodide, and it is to this fact that our failure to prepare this salt is due.

The action of dried methyl-iodide vapour on heated copper-oxide appeared to the author to form a promising method for securing cupric iodide, and, as the vapour of the alkyl iodides can be readily dried over phosphorus-pentoxide, it was hoped that the iodide, once formed, would not suffer the usual decomposition.

* Waite : Rec. Aust. Mus., vol. 5, p. 24, 1903.

The apparatus consisted of a distillation-flask containing the alkyl iodide and phosphorus-pentoxide, two U tubes containing the same drying reagent, a further U tube containing carefully dried copper-oxide, and an upright condenser connected to a receiver with suitable guard-tubes. Between the distillation-flask and the first drying-tube was interposed a T piece that allowed the entry of dry carbonic acid. After the whole apparatus had been sealed together, glass to glass, the various U tubes were heated to the required temperature and the apparatus exhausted. Dried carbonic-acid gas was then allowed to stream in, and, in order to insure the complete absence of oxygen, as well as complete drying, this operation was repeated about thirty times.

A preliminary experiment showed that at a temperature of 310° C. the oxide reacted quickly with the iodide, while at this temperature the vapour of the volatile alkyl compound suffered no decomposition. The rate at which the iodide distilled could be readily controlled, and it was generally so regulated that about 80 grammes were distilled over in 45 minutes.

A few experiments sufficed to show that the reaction, instead of taking the course represented by the equation $CuO + 2\ CH_3I = CuI_2 + (CH_3)_2O$, took a much more complex path, the ultimate solid product invariably being cuprous iodide. Since not the slightest liberation of iodine was noted, as would occur were the cuprous iodide formed by the decomposition of the unstable cupric salt, it is to be concluded that cuprous iodide is the primary product of the reaction.

Numerous other products of the reaction were also obtained. The distillate always gave a strong aldehyde reaction, and it was also possible to collect a considerable quantity of gas. This proved to contain oxygen, carbon-monoxide, ethylene, methane, and its homologues. When methyl-iodide was used, the first three gases were contained to the extent of about 3 per cent., while the methane series bulked very largely in the total. The substitution of ethyl-iodide for methyl-iodide caused a marked change in the ratio of saturated to unsaturated hydrocarbons, for the percentage of ethylene rose to about 50 per cent., while the saturated hydrocarbons fell from about 90 to 45 per cent.

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6. *The Nature of Gamma Rays.*

By Professor T. H. Laby and P. W. Burbidge, B.Sc., Senior University Scholar.

[*Read before the Wellington Philosophical Society, 12th July, 1911.*]

Dr. E. von Schweidler pointed out in 1905 that an effect such as ionization by α rays due to a finite number of independent events would be subject to fluctuations. The mathematical theory of the different experiments which have been made with light, α and β rays, has been developed by Mr. N. R. Campbell.

One of us began some preliminary experiments in 1908 at the Cavendish Laboratory to detect discontinuous effects with γ rays. Two forms of apparatus have been used in our experiments. In the first two similar cylindrical ionization-vessels were placed close together with their axes directed to the source of the γ rays—some radium. If the γ rays have

a spherical wave-front. the two similar vessels, being symetrically placed with respect to the source, should be equally effected by the γ rays, though the results of the equal effects may not be the same. If, on the other hand, the γ rays are any type of corpuscular radiation (in the Newtonian sense) made of a finite number of particles, the effect in the ionization-vessels would be unequal over short periods of time. To compare the number of ions produced in the two vessels, the electrodes were connected to an electrometer, one vessel being positively the other negatively charged. The positive and negative currents from the two cans were balanced as closely as possible for long periods of time, and so there was no large steady drift of the electrometer. The quartz fibre electrometer (Proc. Camb. Phil. Soc., vol. 15, p. 106, 1909) showed fluctuations in this balance. In the second apparatus a box-shaped ionization-can with a central plane electrode was used. The positive ions formed in one half of the can were received on one side of the flat electrode, the negative ions from the other half of the can on the other side of the electrode. By making the can airtight and thoroughly drying the contained air, complete "saturation" was produced with a field of only 8 volts per cm. Large fluctuations were observed when the ionization currents from the two halves were balanced, the source of γ rays being placed outside the can in the plane of the central electrode. This experimental result would be explained if (1) the γ rays from radium are projected particles, or (2) if the number of ions produced in air by a constant source of rays is subject to fluctuations.

We are continuing the experiments with a view to determining what part each of these factors plays in producing the fluctuations observed.

The radium used in these experiments was lent by the Royal Society of London.

ABSTRACTS.

1. Die Gattung Townsonia *Cheesem.* By R. Schlechter. (Abstract from Fedde, Repertorium ix, pp. 249–250 ; 1911).

The genus *Townsonia* was originally published by T. F. Cheeseman in 1906 in the "Manual of the New Zealand Flora" (p. 691), and was placed in the vicinity of *Adenochilus* Hook. f. When Dr. Schlechter undertook a new arrangement of the *Polychondreae* (equivalent to the *Neottieae* of other authors) he was unable, through the absence of specimens, to decide on the exact relationships of the genus. Having received a copious suite from its describer, he has now been able to study it in detail. He has arrived at the conclusion that it is best placed between *Acianthus* R. Br., which is found in Australia and New Caledonia as well as in New Zealand, and *Stigmatodactylus* Maxim., which has three species in Japan, India, and Java respectively. At the same time, there is an undoubtedly strong resemblance to the subfamily *Caladeniinae* in the broadly winged column, a character which is not found in *Acianthus* and allied genera. On the other hand, the smooth labellum, devoid of any projections or protuberances beyond two obscure ridges at the base, and the habit of the plant, point towards the *Acianthineae.* A remarkable character, which is not shown by any *Acianthus,* is that the flowering-stems often produce offshoots which bear solitary radical leaves. The petals are much reduced in size, but this peculiarity is approached by some of the New Caledonian species of *Acianthus,* although not carried to the same extent. The elongated finger-like rostellum much resembles that of *Stigmatodactylus.*

As soon as specimens of *Townsonia* were examined, it was noticed that it was closely allied to *Acianthus viridis* Hook. f. from Tasmania. This led to a careful examination of the Tasmanian plant, which resulted in proving that it also was a genuine *Townsonia,* closely allied to but clearly distinct from the original *T. deflexa. Townsonia* will therefore rank as a typical austral-antarctic genus, with one species—*T. deflexa* Cheesem.—confined to the South Island of New Zealand, the other—*T. viridis* (Hook. f.) Schlechter—endemic in Tasmania.

T. F. C.

2. Some Constants of Mutton-bird Oil and Fat. By L. Hewgill Smith. (Journ. Soc. Chem. Industry No. 7, vol. 30, p. 405 : 15th April, 1911.)

The mutton-bird (*Oestrelata lessoni*), a petrel peculiar to the Antarctic, when disturbed ejects from its nostrils an oil with considerable force. This oil—the first bird-oil to be put on the market—in colour varies from bright ruby red to straw, with not unpleasant fishy smell. On treatment with sulphuric acid the ruby colour is destroyed and straw oil results. At 0° C. the oil solidified to a translucent mass. One specimen contained 2·23 per cent. free fatty acids (as oleic acid). Constants : Specific gravity, 0·8819–0·8858 at 15·5° C. ; saponification value, 125·9 ; iodine value (Wijs), 71 per cent. ; unsaponifiable (alcohols), 36·88 per cent. ; melting-point of alcohols, 30·5–31·5° C. It yields no glycerin. It appears that the oil is not a glyceride, but a liquid wax resembling arctic sperm-oil to a remarkable degree, and, like it, showing no tendency to gum. It was suggested in discussion that the oil contains a large amount of cetyl oleate. The body-fat of the bird, of soft consistency, brown colour, and strong fishy smell, contained 3·5–4·3 per cent. free fatty acids (as oleic acid) ; iodine value (Wijs), 89·1 per cent. ; unsaponifiable matter, 1·76–2 per cent. ; specific gravity, 0·9351–0·9380 at 15·5° C. ; titre test, 29·4° C.

B. C. A.

3. An Attempt to introduce Olearia semidentata into the British Isles. By A. A. Dorrien-Smith. (Kew Bulletin, No. 4, pp. 120–126, 8 photos ; 1910.)

A popular account of a short excursion to the Chatham Islands by the author in quest of living plants. A general account is given of the vegetation of the main island.

Veronica gigantea, 20 ft. high, was seen in full flower; its seedlings are noted as being very different to the mature trees, "the leaves being larger and covered with downy hairs, while the stems are of a reddish-purple colour." The author considers *Plagianthus chathamicus* Cockayne distinct from *P. betulinus* A. Cunn. In some places *Marchantia cephaloscypha* covers bog an acre in extent. The vegetation of a sea-cliff at Te Tuku consisted of *Phormium tenax*, a long grass (probably *Festuca Coxii* Hack.), *Astelia nervosa*, *Veronica chathamica*, *Geranium Traversii*, *Aciphylla Dieffenbachii*, *Senecio lautus*, *S. radiolatus*, *Myosotidium nobile*, *Urtica australis*. The *Myosotidium*, *Phormium*, and *Aciphylla* are threatened with extinction.

L. C.

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4. **New Zealand Plants.** By A. A. Dorrien-Smith. (*Gardeners' Chronicle*, vol. 49, p. 58; 1911.)

The author brought from New Zealand to England 2,000 plants, comprising 217 species. Of these, he lost 45 species on the voyage. Amongst those landed in good condition 38 species were new to cultivation in the British Islands. A list of these is given, and, amongst others, it includes *Aciphylla Dieffenbachii*, *Astelia montana*, 6 species of *Celmisia* (including *C. Rutlandi*), 3 species of *Dracophyllum*, *Olearia semidentata*, *Podocarpus acutifolius*, *Ranunculus lobulatus*, *Rubus Barkeri*, *R. parvus*, *Veronica Astoni*, and *V. Bollonsii*. This latter is a species from the Poor Knights Islands, of which the reviewer hopes shortly to publish a diagnosis.

L. C.

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5. **Remarkable Instances of Plant-dispersion.** By G. Henslow. (Journal Royal Horticultural Society, vol. 35, pp. 342–351; 1910.)

In this paper the author repeats the assertion that white clover wiped out *Phormium tenax* in New Zealand, but that the former was ousted by *Hypochaeris radicata*; further, that the latter in less than three years wholly destroyed excellent pastures and *absolutely* displaced every other plant on the ground. Reasons are assigned for this (alleged) vigour in white clover and other introduced plants, such as—the climate favouring duration of life; more than one crop of seeds in a year; scarcity of graminiverous birds. Further, it is stated that annual weeds which in England would have no chance with perennials "have spread in *inconceivable quantities* into the wildest glens, before either white men or even their cattle and flocks penetrate their recesses."

L. C.

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6. **Olearias in Ireland.** By C. F. Ball. (*Gardeners' Chronicle*, vol. 49, pp. 52–53; 1911.)

An account of the species of *Olearia* in cultivation at the Glasnevin Botanical Gardens, Dublin. Eighteen are New Zealand species. Amongst others are *O. chathamica*, *O. insignis*, *O. Lyallii*, and *O. lacunosa*.

L. C.

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7. **Hybrid Veronicas.** By Editor of *Gardeners' Chronicle*. (*Gardeners' Chronicle*, vol. 48, p. 103; 1910.)

An account of the following hybrid Veronicas raised by Mr. Lindsay, formerly of the Royal Botanic Gardens, Edinburgh: *V.* x *myrtifolia* is the result of a cross between *V. Balfouriana* (♀) and *V. salicifolia* (♂). *V.* x *edinensis* had *V. Hectori* for ♀ parent and *V. pimelioides* for ♂ parent. The cross is closely allied to *V. epacridea*, if not identical.

L. C.

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PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1911

PART II

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NEW ZEALAND INSTITUTE.

1911.

PART II.

PROCEEDINGS.

WELLINGTON PHILOSOPHICAL SOCIETY.

FOURTH MEETING: *9th August, 1911.*

Mr. G. V. Hudson, President, in the chair, and about sixty members and friends present.

New Members.—Captain G. S. Hooper and Mr. J. G. Wilson.

Papers.—1. "The National Home Reading Union." By Thos. King, F.R.A.S.

2. "Immunity; or, How the Body defends itself against its Microbic Foes." By J. M. Mason, M.D., F.C.S., D.P.H. Camb.

3. "Notes on *Salicornia australis*." By Miss Cooke, M.A.; communicated by Professor Kirk.

4. "Hoisting the Flag at Akaroa: an Incident of 1840." By Miss E. M. Jacobson, M.A.; communicated by C. E. Adams.

5. "Notes on Dragon-flies from the Kermadec Islands." By R. J. Tillyard, M.A., F.E.S.; communicated by A. Hamilton.

6. "Longitude of the Hector Astronomical Observatory, Wellington." By C. E. Adams, M.Sc., F.R.A.S.

7. "Wellington Tidal Records." By C. E. Adams, M.Sc., F.R.A.S.

FIFTH MEETING: *6th September, 1911.*

Mr. G. V. Hudson, President, in the chair, and about fifty members and friends present.

New Member.—Mr. W. F. Howlett, B.A., Oxon.

Papers.—1. "Notes on New Zealand *Acarina*." By J. B. Gatenby.

This paper comprises descriptions of about fifty New Zealand *Acarina*, which belong to *Trombidium*, *Notophallus*, *Linopodes*, *Erythraeus*, *Bdellus*, *Anystes*, *Cyta*, *Tyroglyphus*, *Ixodes*, *Gamasus*, *Uropoda*, and several other more or less doubtful

genera. As the author intends to leave for England, where the best libraries will be at his disposal, it was thought better to temporarily withhold publication with a view to finding out whether any of the species had been described before by European acarologists. Amongst other interesting *Acarina* dealt with in the paper is the description of an acarid (genus *Ixodes*) found on the tuatara lizard.

2. "Account of some Exploration of, and the Discovery of Former Glaciation in, the Tararua Ranges." By G. L. Adkin.

3. "The Raised Beaches of Cape Turakirae." By B. C. Aston, F.I.C., F.C.S.

4. "On a Collection of *Mallophaga* from the Kermadec Islands." By T. Harvey Johnston, M.A., D.Sc., and Launcelot Harrison; communicated by A. Hamilton.

5. "On the Migrations of the Polynesians according to the Evidence of their Language." By Professor J. Macmillan Brown.

AUCKLAND INSTITUTE.

SECOND MEETING: *7th August, 1911.*

Mr. J. H. Upton, President, in the chair.

New Members.—Messrs. T. Bassett, A. G. Lunn, W. H. Webbe, W. E. Woodward.

Lecture.—"Sources of Plague in Auckland, and its Prevention." By R. H. Makgill, M.D.

The lecturer briefly alluded to the history of plague, which he said was the most anciently known of diseases, the first record being at least four thousand years old; and traced the more important epidemics of plague during historic times. During the nineteenth century, however, the old endemic centres of the East had become practically free from plague, and the present widespread prevalence of the disease had been traced to the Chinese province of Yun-nan, in which it appears to be truly endemic. It reached India in 1896, and, favoured by the rapid transit of modern times, found its way to Australia and New Zealand in 1900. In Auckland in the past eleven years there has been twenty certain cases of plague, nine of them being fatal. The characteristic disappearance of the disease for intervals manifested itself during that time. In 1901 there was one case, in 1902 none, in 1903 three, in 1904 two, in 1905 and 1906 none, in 1907 two, in 1908 and 1909 none, in 1910 three, and 1911 eight. As plague was usually discoverable in rats in Sydney, it might reasonably be supposed to have been absent during the intervals, and to have been reintroduced by rodents brought across. Point was lent to this supposition by the fact that the first case after the last interval occurred in a man who had been handling goods from Sydney. But until quite recently the examination of rats had not been sufficiently widespread to make it quite certain that the disease had not remained in the rats of the locality.

The lecturer pointed out that it was now perfectly well established that the rat carried the disease from place to place, and that infected rats were always found to precede cases of human plague. When the disease was once firmly established among the rats of any city, then the rat-flea became the carrier of the disease from rat to man. Now, fleas, and to a smaller extent rats, are always much more abundant in summer and autumn than at any other time of the year. Hence we find that the twenty cases of plague in Auckland had occurred as follows: Five in March, three in April, seven in May, and five in June. In combating plague, constant war must be waged against the rat and the flea. One of the first lines of defence was the water-front; and the ferro-concrete wharves, as far as they had been adopted in Auckland, had brought about a great reduction in the rat-population. But much remained to be done in the city itself. Eternal vigilance was the price of immunity from plague. Spasmodic effort could not take the place of continuous hard work, and hysteria was dangerous. Every one must keep his premises, and especially his business premises, clean, and encourage others to do the same: and care should be taken to elect to the local governing bodies men who would see that sanitary laws were effective and properly executed.

THIRD MEETING: *28th August, 1911.*

Mr. J. H. Upton, President, in the chair.

New Members.—R. Burns, W. Coleman, H. C. Choyce, Bishop Crossley, G. Dunnett, J. W. Ellis, Dr. W. A. Fairclough, Dr. G. Fenwick, Rev. H. A. Favell, H. T. Gorrie, J. H. Gunson, H. R. Hesketh, Dr. P. A. Lindsay, S. Milroy, W. F. Napier, S. J. Nathan, P. Oliphant, A. B. Roberton, W. Ware, W. S. Whitley, J. W. Wiseman, Captain C. A. Young.

Lecture.—"Heredity." By Professor A. P. W. Thomas, M.A.

The lecturer explained the scientific facts upon which the modern theories of heredity are based, illustrating his remarks by carefully prepared diagrams and numerous lantern-slides.

Especial weight was given to the researches of Weismann, and to the totally new light which the tardy recognition of Mendel's laws had thrown upon the subject. He then passed on to the subject of eugenics, now becoming so prominent, and pointed out what could be reasonably expected from it, and what effects of importance on the physical and mental characters of mankind might be anticipated if the principle ever came within the range of practical achievement.

A very hearty vote of thanks was passed to Professor Thomas at the close of the lecture.

FOURTH MEETING: *2nd October, 1911.*

Mr. J. H. Upton, President, in the chair.

New Members.—W. E. Arey, W. R. Bloomfield, G. Court, J. Court, G. Elliott, D. Hay, C. T. Major, L. Myers.

Lecture.—"Whirling Discs and their Uses." By Professor F. D. Brown, M.A.

In this lecture Professor Brown discussed the principles of gyroscopic motion, pointing out that the gyroscope, which at one time was regarded as little more than a scientific toy, though a very interesting one, had now, through the modern development of mechanism, been found to have many possibilities of application to ships, motor-cars, aeroplanes, and railways, to say nothing of minor examples. A great number of experiments with different forms of gyroscopes, &c., were exhibited to the meeting, and fully explained. A model of the Brennan mono-rail was also exhibited, and made to travel along a wire stretched across the lecture-room. On the motion of the President, a vote of thanks was passed to Professor Brown by acclamation.

MANAWATU PHILOSOPHICAL SOCIETY.

FOURTH MEETING: *31st August, 1911.*

Captain Hewitt, R.N., in the chair.

Exhibit.—A fine specimen of volcanic rock brought by the "Terra Nova" from Mount Erebus, and presented to the Society by Mr. J. J. Kinsey, was exhibited, and descriptive notes thereon communicated by Miss Souper were read by the Secretary.

The rock was described as an alkaline basalt or trachydolerite, intermediate in type between ordinary basalt and phonolite, almost precisely identical in character and chemical composition with the kenytes of Mount Kenya and the rhomb-porphyries of Mount Kilimandjaro recently described by Dr. Finkh.

Paper.—"Memory: What is it?" By Sir Robert Stout.

The paper defined memory as the storing-up of past impressions, including therein not merely the impressions received by the individual, but those also inherited from countless generations of ancestors. This was illustrated by instances of the marvellous instinct shown by insects and larger animals, and also by the transmission of special talents in particular families, such as those of Bach, Darwin, and Gregory. Quoting Walt Whitman's saying that "Every hour of light and dark, and every inch of space, was a miracle," the speaker laid stress upon the fact that nature's methods were not only miraculous but very slow, and that any attempt to unduly hasten them in the desire for progress was sure to end in failure.

On the motion of the Chairman, a hearty vote of thanks was accorded to the lecturer.

FIFTH MEETING: *28th September, 1911.*

Captain Hewitt, R.N., in the chair.

The President announced that at the last meeting of the Council ten new members were elected; and that, as the alterations in the fire-brigade building kindly undertaken by the Borough Council were now nearly completed, he hoped that the Museum would be ready to be opened in the new premises by the end of October. Mr. Hamilton had very kindly promised, with the permission of the Minister of Internal Affairs, to superintend the arrangement of collections; and several firms and offices had promised valuable additions, illustrating the different forms of local industry.

Paper.—Mr. J. E. Vernon, M.A., read a paper on "Recent Local Weather," describing the different instruments belonging to the Society which had been in his charge for the last four months, and giving statistics of local rainfall, temperature, barometric pressure, and wind.

OTAGO INSTITUTE.

FOURTH MEETING: *1st August, 1911.*

Present: Mr. A. Bathgate, President, in the chair, and about twenty others.

New Members.—Dr. R. Church, Messrs. Sydney Beaumont, A. W. Bethune, A. Davis, and W. Gillanders.

Astronomical Society.—The chairman announced that the Astronomical Society had accepted the proposed terms of amalgamation with the Institute, and that the Society's members would shortly be elected members of the Institute, forming a separate branch in the same way as the Technological Society had done.

Exhibit.—Mr. D. Tannock exhibited some fine specimens of *Primula sinensis,* grown by himself in such a way as to exhibit mendelism. Both Mr. Tannock and Dr. Benham, in speaking of the exhibit, referred to the fact that mendelism had been of great service to horticulturists and agriculturists, instancing several changes that had been brought about by the application of Mendel's laws.

Papers.—1. "New Species of *Lepidoptera.*" By G. W. Howes, F.E.S.

2. "On the Larvae and Pupae of some New Zealand Butterflies." By G. W. Howes, F.E.S.

3. "The Food Value of Kumaras." By Dr. J. Malcolm.

Of the kumara, two-thirds consisted of water; carbo-hydrates were present in the kumara to the extent of 19 per cent. of the whole. The sweet taste of the kumara was due to the presence of a substance which promoted a plentiful flow of saliva, which converted the starch into sugar. There was only 0·27 per cent. of fat in the kumara. It was a vegetable that did not keep well. Mould grew quickly, owing to the presence of sugar; the ordinary potato was not so affected, owing to the absence of glucose.

4. "The Application of Phonetics to English Pronunciation," and "The Question of a New Zealand Dialect." By G. E. Thompson, M.A.

Nearly all of the English dialects could be heard in New Zealand, but people born in this country and educated in its schools showed a uniformity of pronunciation. New Zealand speech was more like the southern English type, and least like the Scottish. As the Dominion was only some fifty years old, the difference in speech was very slight. The chief and noticeable feature was the distinct tendency, when uttering vowel sounds, to lower the tongue, the result being the expression of more open vowel sounds and a mispronunciation (in the vowels) of such words as "sea," "twelve," "mood," "put." These differences in pronunciation showed what was probably the beginning of a distinctly New Zealand dialect. In the discussion that followed Mr. Morrell advocated the inclusion of the study of phonetics in the curriculum of our training colleges.

FIFTH MEETING: *5th September, 1911.*

Present: Mr. A. Bathgate, President, in the chair, and fifty others.

New Members.—Messrs. T. B. Hamilton, M.A., B.Sc., C. E. Pfeifer, R. Price, A. L. Murray, T. Thomson, and the following members of the Astronomical Society: Professor J. M. E. Garrow, B.A., LL.B., Wellington (life member), Mr. W. H. Price (life member), Rev. Bro. Brady, Rev. D. Dutton, F.R.A.S., Rev. P. W. Fairclough, F.R.A.S., Messrs. E. Anscombe, O. Balk, James Bremner, A. C. Hanlon, J. W. Milnes, H. E. White, G. R. Hercus, J. Loudon, Tompson Lamb, J. F. Morris, W. G. Somerville, J. Swann, C. S. Smith, W. S. Wilson, and Mrs. Buckland.

Address.—"Soap-bubbles and the Forces that mould them." By E. E. Stark, M.Am.I.E.E.

The address was illustrated by a very large number of experiments with soap-films.

SIXTH MEETING: *3rd October, 1911.*

Present: Mr. A. Bathgate, President, in the chair, and about twenty-five others.

New Member.—Mr. L. J. Wild, B.A.

Exhibit.—Dr. Benham exhibited a plaster mould and gelatine cast of a warehou or sea-bream as an illustration of the modern method of mounting museum specimens of fishes, contrasting it with the result obtained by the old method of stuffing the dried skins.

Papers.—1. "Some Rocks of Mount Cargill." By J. A. Bartrum, M.Sc.; communicated by Dr. Marshall.

2. "Geology of the Bluff." By L. J. Wild, B.A.; communicated by Dr. Marshall.

3. "Report on Sundry Invertebrates from the Kermadec Islands." By Dr. W. B. Benham, F.R.S.

4. "Description of Three New Species of *Lepidoptera*." By Alfred Philpott; communicated by Dr. W. B. Benham, F.R.S.

5. "Vascular System of *Siphonaria obliquata*." By A. J. Cottrell, M.A., M.Sc.; communicated by Dr. W. B. Benham, F.R.S.

6. "Structure of the Nephridium of the Earthworm *Maoridrilus rosae*." By Miss G. Cameron, M.Sc.; communicated by Dr. W. B. Benham, F.R.S.

7. "The Plant Covering of Codfish Island." By D. L. Poppelwell.

Observations on the flora of Codfish and Rugged Islands (Stewart Island) made by the author on a recent visit there, and a comparison of it with that of Stewart Island.

8. "The Food Value of Frostfish." By Dr. J. Malcolm.

The waste in frostfish amounts to over 30 per cent. In the remainder the percentage of fat varies from 5 to 8 in the flesh of the sides, and rises to over 16 per cent. in the part surrounding the body cavity. The frostfish must therefore be classified as one of the less digestible kinds of fish. The amount of protein is about 16 per cent. No glycogen was detected.

9. "An Ancient Maori Stone-quarry." By H. D. Skinner.

A description is given of an ancient tool-manufactory near the Dun Mountain, in the Upper Maitai Valley, Nelson, and of the processes employed in breaking the stone and fashioning the tools.

TECHNOLOGICAL SECTION.

THIRD MEETING: *18th July, 1911.*

Mr. E. E. Stark in the chair.

Address.—Mr. F. W. Furkert, District Engineer of the Public Works Department, gave an address on "The Hapuawhenua Viaduct."

The lecturer, in addition to giving a detailed description of the structure itself, illustrated by lantern-slides, gave an interesting account of the history and building of the viaduct, and of the nature and climate of the Hapuawhenua country.

FOURTH MEETING: *15th August, 1911.*

Mr. E. E. Stark in the chair.

Address.—"The Stability of Ships." By Mr. H. McRae.

FIFTH MEETING: *19th September, 1911.*

Present: Mr. E. E. Stark (in the chair) and a large number of members.

Lecture.—Professor D. B. Waters: "Coal—its Classification and Analysis."

In concluding his address, Professor Waters referred to the experiments that had been going on at St. Louis to determine the best use to which inferior coals could be put, and to ascertain the relative cost per horse-power generated by coal and by producer-gas. These experiments were still going on, and in America the use of gas-engines was rapidly increasing. He thought the Government, through the Mining Department, should take steps to ascertain what uses could be made of the inferior coal in the Dominion.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

FOURTH MEETING: *2nd August, 1911.*

Present: Mr. A. M. Wright, President, in the chair, and eighty others.

New Member.—Mr. S. S. Blackburne.

Kapiti Island Sanctuary.—The following resolution was carried: "That the Philosophical Institute of Canterbury desires to express its cordial approval of the enlightened action of the Government in declaring Kapiti Island a sanctuary for the birds and animals of New Zealand, and hopes that the proposal to use it as a holiday resort as reported in the *Lyttelton Times* of 1st August is not seriously contemplated. Its reservation as a sanctuary is already widely known and cordially approved by naturalists throughout the world, and specially so seeing that it is ideally situated for the purpose. Its use in the manner proposed not only would inevitably undo all the good which has resulted from its original reservation, but it would be universally regarded as a retrograde step, and out of keeping with the admirable policy of the Government in providing adequately for our native fauna and flora."

Paper.—Observations concerning Evolution derived from Ecological Studies in New Zealand." By Dr. L. Cockayne, F.L.S.

The paper on which the address was based had been previously circulated amongst members, as the details were too numerous and technical for submitting to a mixed audience. The following heads were dealt with: Elementary species, variation, mutation, epharmony, persistent juvenile forms, hybridization, the struggle for existence, distribution of species, and evolution in the genus *Veronica*. The address was illustrated by forty lantern-slides.

A critical discussion followed, in which Drs. Hilgendorf and Chilton and Messrs. Laing and Andersen took part.

FIFTH MEETING: *6th September, 1911.*

Present: Mr. A. M. Wright, President, in the chair, and forty others.

New Member.—Mr. T. D. Burnett.

Addresses.—1. "Bogs and their Bearing on Climate." By Mr. R. Speight.

The lecturer gave a *résumé* of the work which has been done recently in Sweden, Scotland, and the United States in this department of science, and sketched the general tendency of the conclusions as to the variations of climate since the last period of glaciation. A number of lantern-slides were shown illustrative of bogs and peat-deposits in various parts of the world, including New Zealand, and the lecturer expressed a hope that it might be possible to examine some of our own bogs by modern methods.

2. "Modifications of Deep-sea Fish to suit their Environment." By Mr. Edgar R. Waite.

The lecturer gave a most interesting account of the modifications of deep-sea fish to adapt themselves to their condition of life, and specially to the effects of pressure in the abyssal depths, and to the absence of light. A number of excellent

slides showing the grotesque varieties of form and the lures with which these fish attract their prey, and the modifications of the mouth and stomach to deal with it when caught, were displayed on the screen.

Papers.—1. "A Redescription of *Aegaeonichthys appelii*." By Edgar R. Waite.

2. "Miscellaneous Notes on some New Zealand *Crustacea*." By Dr. Charles Chilton.

Exhibit.—A specimen of *Veronica lycopodioides* was exhibited and described by Mr. R. Nairn, who said that the specimen under consideration had been grown in a greenhouse from cuttings, and had put forth not only larger leaves than it usually showed when growing wild, but also the leaves of the ordinary form. This he attributed to the influence of the warm, still, and damp atmosphere of the greenhouse.

SIXTH MEETING: *4th October, 1911.*

Present: Mr. A. M. Wright, President, in the chair, and seventy-five others.

New Members.—Misses Sanders and Izard, and Mr. Henry Suter.

Address.—"Profit-sharing." By Mr. A. W. Beaven.

The lecturer in his introductory remarks said that neither employer nor employee was satisfied with the present wages system, but he was not in a position to formulate a remedy for the defects of that system. The lecturer dealt with the nature of capital and with the evolution of the modern industrial system. He said that socialism, co-operation, and profit-sharing had been suggested as remedies for the present defects. His personal opinion was that though compulsory socialism might be successful in equalizing the division of products, it is certain that there would be less products to divide than at present. Co-operation had failed generally because of the rarity of organizing and directing ability. Profit-sharing was a modification of the wages system which made the worker a partner to a specific extent in the profits realized.

The speaker gave instances of cases in which profit-sharing had been tried in industries. He gave full details of the following cases—the French house of Le Clair, of the Pillsbury Flour-mills in Minnesota, of the South Metropolitan Gas Company in London—and brief reference to numerous other cases where the scheme had been successful, as well as to others where it had been unsuccessful. In conclusion, the lecturer said that the examples he has quoted led him to consider that profit-sharing was practicable and advisable. It was necessary that any arrangement made should have an element of permanency, and should not be dependent upon the arbitrary action of the employer. Every system should be suited to the business to which it was applied. The ideal trade-union would be that in which employer and employed were united to advance the interests of the industry by which they earned their livelihood.

At the conclusion of the address Dr. Hight pointed out that in estimating the effects of profit-sharing they must inquire whether the conditions prevalent in any two businesses were quite the same. In some cases success was partly due to the business having a partial monopoly, as in gas companies, and in other cases to special organizing ability. He also pointed out that there had been a steady decline in profit-sharing in England, and that the method was only a palliative and gave no ultimate solution of the labour problem.

The lecturer was accorded a hearty vote of thanks.

Papers.—1. "New Plant-habitats," Part VII. By Dr. L. Cockayne.

2. "Descriptions of New Species of Plants." By Dr. L. Cockayne.
(See page 50.)

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

THIRD MEETING: *30th June, 1911.*

The President, Mr. H. Hill, B.A., F.G.S., in the chair.

Papers.—1. "The Haslemere Educational Museum." By Mr. F. Hutchinson, jun.

This paper outlined the principles on which the Museum, founded by the author's uncle, was based. Geological and historical specimens, books, pictures, and other articles were arranged chronologically. A herbarium and a vivarium formed part of the Museum, and in these fresh specimens from the surrounding district were kept according to the season. Specimens were for sale. Questions to encourage thought were on the labels—*e.g.*, "What is the best quality of the bird?"

2. "Moa-remains from Wainui Beach." By W. Townson; communicated by J. Niven, M.A., M.Sc.

As the result of the interest aroused by these papers, a number of gentlemen volunteered to rearrange and classify the objects in the Napier Museum if the Borough Council, the controlling authority, would agree. The Borough Council were to be asked to help in the matter of making the Museum more up to date.

Finances.—Mr. Hill was appointed to interview the member for the district with regard to more financial help for the New Zealand Institute.

FOURTH MEETING: *1st September, 1911.*

The President, Mr. H. Hill, B.A., F.G.S., in the chair.

New Members.—W. Scott, W. Murphy, W. Morris, W. Smith, B.A.

Papers.—1. "Pore Space and the Influence of Surface Tension on the Moisture in the Soil." By W. Morris.

This paper dealt principally with the relation between volume and surface of particles of different kinds of soil, and the effect of the comparatively enormous surface of the soil-particles on the passage of water through the soil.

2. "Fungi and their Relation to Domestic Life." By E. G. Loten. Illustrated. (To be continued.)

PAPERS.

1. *Descriptions of some New Species of New Zealand Plants.*

By L. Cockayne, Ph.D., F.L.S.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1911.*]

1. *Nertera Balfouriana* Cockayne sp. nov.

Herba perennis, glabra. Caulis repens, gracilis, ramosus, radicans. Folia late oblonga v. subrotundata, 2·5–3 mm. longa, 2–2·5 mm. lata, petiolata, basi rotundata v. cuneata; petiolus circ. 2·5 mm. longus, supra canaliculatus. Flores non visi. Drupa pyriformis, 7–9 mm. longa, aurantiaca.

South Island: Canterbury — Rakaia, Ashburton, and Rangitata Valleys, at altitude of about 600–800 m., R. M. Laing and L. C.; Waimakariri Valley, at about same altitude, L. C.; neighbourhood of Mount Cook, D. Petrie. Grows in *Sphagnum* bogs.

N. Balfouriana is at once distinguished from all the other New Zealand species by its large pyriform orange-coloured drupes, which are produced in such profusion as to quite hide the leaves. The plant forms close patches on *Sphagnum* cushions, the stems and leaves being frequently hidden amongst the moss. When in full fruit it is a beautiful object, and should be a rival of *N. depressa* Banks and Sol. as a plant for rock-gardens. The fruits are ripe during March and April.

The plant is named in honour of Professor I. Bayley Balfour, F.R.S., who, as Regius Keeper of the Royal Botanic Garden, Edinburgh, has done much to make known the horticultural capabilities of the New Zealand alpine flora.

2. *Veronica Bollonsii* Cockayne sp. nov.

Frutex erectus, glaberrimus, circ. 1·5 m. altus, multiramosus ramis teretibus. Folia obovato-oblonga, glabra, lucida, 2–6 cm. longa, 1–3 cm. lata. Racemi folia superantes, 10·5 cm. longi, vix densiflori, rhachibus pedicellisque brevissime pubescentibus; pedicelli 3 mm. longi. Flores palide lilacini. Calyx profunde 4-partitus, corollae tubum fere aequans, 3–3·2 mm. longus; lobi anguste lanceolati, acuti, ciliolati. Corollae tubus 3–4 mm. longus, fauce pubescens; lobi ovati, obtusi vel subacuti, 4 mm. longi. Capsula ovata, acuta 4·2 mm. longa.

North Island: Auckland—The Poor Knights Islands, L. C. Blooms in cultivation in the neighbourhood of Christchurch in April and later, but the same autumn-blooming plant may flower again in the succeeding summer.

In Trans. N.Z. Inst., vol. 38, p. 354, I referred, but with some measure of doubt, this plant to *V. macroura* Hook. f., for my material, with only fragmentary racemes many months old, was insufficient for accurate determination. Since that time, plants that I raised from cuttings have bloomed both in the garden of Mr. Lough, Linwood, and at Canterbury College, and have proved that the plant is a species quite distinct from any other in New Zealand. It is at once separated from *V. macroura* Hook. f. by the erect habit, glossy somewhat dark-green glabrous leaves with a subapiculate apex, much larger flowers

which are not crowded very closely, glabrous calyx except for scanty cilia on the margin almost equalling the corolla-tube, and ovate obtuse or subacute corolla-segments 4 mm. long as opposed to the oblong ones 2 mm. long rounded at the apex of *V. macroura*. The season of flowering is altogether different. Whether *V. Bollonsii* is identical with the Whangarei plant found by Colenso and referred by Hooker to *V. macroura* I do not know. This latter species, in my estimation, is found only in the East Cape district, the var. *dubia* Cheesem. being a good species as well as the unnamed plant growing in the neighbourhood of Wellington, and which I followed Hooker in referring to *V. macroura*, but considered distinct enough to warrant a varietal name (Trans. N.Z. Inst., vol. 39, p. 361). I also consider *V. Cookiana* Colenso as distinct from *V. macroura*.

V. Bollonsii is dedicated to Captain J. Bollons, to whom not only New Zealand botany, but zoology also, owes much.

3. *Veronica Dorrien-Smithii* Cockayne sp. nov.

Frutex parvus paulo ramosus, ramulis ± incano-pubescentibus. Folia sessilia, oblonga, elliptico-oblonga vel elliptico-lanceolata, circ. 5–6 cm. longa, supra glabra, subtus ad costam pubescentia. Racemi folia aequantes vel paulo superantes, minute pubescentes. Calyx brevis, profunde 4-partitus, 1·9 mm. longus; lobi late ovati, acuti vel apiculati, ciliati. Corollae tubus 2·5–2·8 mm. longus, fauce pubescens; lobi obovati, 2·8 mm. longi. Ovarium glabrum; stylus vix exsertus. Capsula late ovata, 4 mm. longa, calycem duplo excedens.

Chatham Island: Growing on peaty ground at margin of Lake Tekua Taupo, at an altitude of 240 m. Herb. Cockayne No. 8003. Flowers in December and January; seed ripe in February and March,

V. Dorrien-Smithii is allied to *V. Dieffenbachii* Benth., but is a much smaller plant, and though the branches are straggling they are not widely divaricating. It differs also in the hoary pubescent more slender stems, broader light-green not whitish-green leaves, the very small bracteoles and much shorter racemes. It is a variable plant, but it does not seem to pass into *V. Dieffenbachii*. The stems may be conspicuously hoary or almost glabrous. In one example the leaves measure 9 cm. long by 3·2 cm. broad, in another they are 5 cm. long and 2·8 cm. broad with internodes 2·5 cm. long. The flowers are sometimes lavender at first, then fading to white, or they may be white from the beginning.

A plant growing under the waterfall at Te Awatapu is so distinct as to merit a varietal name if it is constant from seed. The stems are slender and straggling. The leaves are narrower than the type, darkish-green, 5·5 cm. long and 1 cm. broad; the midrib is purple; the raceme slender, half as long again as the leaves, with the flowers rather distant; the pedicels and base of the calyx dark red-purple and the stigma hardly exserted. The flowers are lilac, changing to white. The plant is in cultivation in my garden, and there is a specimen, No. 8005, in my herbarium.

The species is called after Captain A. A. Dorrien Smith, D.S.O., who recently collected what I take to be a form in Chatham Island, and who likewise is paying great attention to the cultivation in England of New Zealand trees and shrubs.

4. *Celmisia lanceolata* Cockayne sp. nov.

Herba perennis Celmisiae coriaceae habitu. Folia ensiformia vel lineari-lanceolata, circ. 24–28 cm. longa, 2–2·6 cm. lata, acuta, rigida,

coriacea, margine valde recurvo, supra longitudinale sulcata, glauca, cuticula pellucida vestita, subtus dense sericeo-tomentosa; nervus medius supra luteo-aurantiacus, prope basim 3–5 mm. latus, subtus carinatus. Scapi compressi vel teretes, circ. 32 cm. longi, niveo-lanati; bractae numerosae, magnae, ensiformes, scapo adpressae. Capitulum 7·7 cm. diamet.; involucri squamae lineares, acuminatae, scariosae, brunneae ad basim carnosae. Flosculi radii plurimi, angusti, 3·6 cm. longi. Achenium minute pubescens.

South Island: Southland—Longwood Range near summit, but not common, J. Young! H. Reichel! Flowers in January.

Celmisia lanceolata is intermediate in character between *C. coriacea* Hook. f. and *C. Armstrongii* Petrie. It is best distinguished by the large heads, but not so large as reached by *C. coriacea*, the long narrow rays, the stiff woolly scapes with many leaf-like ensiform bracts, the long dull glaucous or yellowish-green linear-lanceolate leaves in erect rosettes with a conspicuous yellow or even orange midrib and widely recurved margin, the broad pale leaf-sheaths, and the very close silvery tomentum.

The scape when compressed is about 6 mm. broad; it is densely woolly with long white matted hairs. The bracts are ensiform, concave on the upper surface, about 11 cm. long by 1 cm. wide, pale yellowish-green with a brownish-yellow midrib. The involucral bracts are green at the fleshy base but brown elsewhere, ciliate, more or less glabrous elsewhere, and about 2·3 cm. long and 3 mm. wide.

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2. *Notes on the Nomenclature of the New Zealand* Geometridae; *with Description of a New Species.*

By L. B. Prout.

Communicated by George Howes, F.E.S.

[*Read before the Otago Institute, 6th June, 1911.*]

The following extracts from the letters of Mr. L. B. Prout are of considerable interest to students of *Lepidoptera* in New Zealand, as several disputed points are settled here:—

Xanthorhoe cinerearia Dbld.

The large form is rightly *semisignata* Walk., and is a true *Xanthorhoe* (discocellular veins of the hindwing simple). Its antennae have about 28 segments pectinated.

Synonyms: *Xanthorhoe semisignata* Walk. = *semilisata* Walk. = *corcularia* Guen. = *dissociata* Walk. = *punctilineata* Walk.

The small form is *cinerearia* Dbld., but is a *Larentia* (discocellulars triangulate), and has about 22 segments pectinated.

Synonyms: *Larentia cinerararia* Dbld. = *diffusaria* Walk. = *infusata* Walk. = *invexata* Walk. = *inoperata* Walk. = *infantaria* Guen. = *adonata* Feld.

Larentia farinata Warr.

L. farinata is of a more unicolorous slaty grey (not brownish-grey) than *cinerararia*, and is larger and more weakly marked. About 21 segments of the antennae are pectinated. Its proximal areole is minute, but this may vary.

An excellent description, from Wellington specimens, is given in "Novitates Zoologicae," vol. 3, p. 388.

Xanthorhoe lucidata Walk.

The insect identified by Hudson as *X. lucidata* is not the typical *lucidata* of Walker. The true *lucidata* is smaller in size, lines less straight, colours more varied, &c. Hudson's species agrees exactly with *veinapuncta* Walk. The whitish dots on the veins are quite characteristic of the species.

Lythria euclidiata Guen.

The large form without any red on the underside is *L. euclidiata* Gn.; the smaller, which answers to Hudson's description and figure, is *catapyrrha* Butl. This latter should be known as *Arcteothes catapyrrha* until it can be proved that the two strikingly different forms are conspecific.

Dichromodes petrina Meyr.

Petrina sinks to an older name—*sphaeriata* Feld.—which was unknown to (or unidentified by) Meyrick, through Felder having assigned it not only to the wrong genus, but to the wrong subfamily, and given rather a poor figure of it.

Epirranthis alectoraria Walk.

Sufficiently distinct from the true *Epirranthis* to form a new genus under the name *Xynonia* (Prout); and included in *alectoraria* are apparently two species—*Xynonia alectoraria*, the long-winged species with the margins irregular; *Xynonia ustaria* (Prout), the stumpier-winged with strong angle (almost a tooth) in middle of outer margin of forewing and with strong dentate margin of hindwing.

Epirranthis hemipteraria Gn.

This should be *Xyridacma hemipteraria:* the singular form of the hindwing renders it convenient to keep it separate from *Xynonia.*

Drepanodes muriferata Walk.

Drepanodes is a South American genus, and, as your New Zealand *muriferata* is probably structurally distinct therefrom, it seems premature to merge them, so advise keeping to the generic name *Gargaphania* Walk. expressly founded for *muriferata.*

Leptomeris rubraria Dbld.

This should be *Acidalia rubraria.* The genus has been known by quite a number of synonyms (*Leptomeris, Craspedia, Emmitis,* &c.), but *Acidalia* is the oldest name for it.

Selidosema.

Selidosema Hubner is a European genus, and probably does not occur in New Zealand. Meyrick (Trans. N.Z. Inst., vol. 17, p. 65) made a genus *Gelonia* for *S. panagrata* and *S. dejectaria.* This had better stand provisionally.

It would be well to use *Pseudocoremia* Butl. for *suavis, lupinata, rudisata* ("*rudiata*" is an orthographical alteration of Hudson's), *melinata, ochrea,* and allies—apparently a quite compact group.

Sestra humeraria and *Sestra flexata* Walk.

Hudson has unfortunately transposed these two. It is really Butler's fault, at least in part, and shows the mischief of premature lumping.

Hudson had to separate the two again, and, of course, could not consult Walker's types.

The species figured by Hudson (pl. ix, fig. 37) as *flexata* is really *S. humeraria* = *obtusaria* = *obtruncata* = *punctilinearia*. The true *flexata* is figured by him on pl. x, figs. 1 and 2, as *humeraria*.

Larentia exoriens Prout nov. sp.

♂. 26–35 mm. Face pale ochreous, strongly tinged with red. Palpus the same, reddest on the outer side. Pectinations rather long. Legs pale ochreous, spotted with fuscous, more or less red on upper side. Vertex and front of thorax sometimes tinged with red. Abdomen with paired dark dorsal dots, which are seldom distinct. Wings shaped as in *aegrota* Butl., pale ochreous; basal and median areas of forewing—and especially costa as far as subcostal vein—sometimes flushed with rosy rufous. Forewing sometimes with an indistinct curved rufous line near base; other lines rufous-grey, arranged nearly as in *aegrota;* subbasal pair oblique (almost parallel with termen), sometimes curved, sometimes rather sinuous, scarcely ever strongly bent basewards near costa as in *aegrota;* median series of four rather variable, the first usually crossing the black cell-spot, the third weak sometimes lost in a greyish suffusion, the fourth dentate usually projecting rather more before and behind the radials than is normal in *aegrota;* a pale band distally to the line, usually bisected by a very feeble grey line; subterminal area usually more or less shaded with grey, at least to the extent of some spots before a pale vague lunulate subterminal line; termen marked with paired black dots; fringe slightly dark-marked, generally more feebly than in *aegrota*. Hindwing with or without black cell-spot, no other distinct markings, faint traces of those on the underside; termen and fringe as in forewing. Underside pale ocherous, in fresh specimens usually strongly flushed with rufous, especially costal terminal areas of forewing and whole of hindwing; basal area, especially of forewing, more greyish, both wings with dark post-median line usually pretty well defined, sometimes dark-shaded proximally, usually pale-margined distally; in well-marked individuals with a distinct pale subterminal line; hindwings also sometimes with one or two dark lines in basal area; cell-spots present; termen as above.

Type (G. Howes, 15th March, 1910) in coll. L. B. Prout.

Glenorchy (March, 1910)—G. B. Longstaff; G. Howes. Nevis (24th March, 1911), Kinloch (20th March, 1911)—G. Howes.

By the kindness of Dr. Longstaff and Mr. Howes I am enabled to describe this species from nine males, including two or three in excellent condition and others little inferior. When worn or faded it is exceedingly similar to *L. aegrota*, but, apart from the points indicated above, it may be known by the absence of strong fuscous clouding on the underside, and by two structural characters: the antennal pectinations are appreciably longer (one-sixth or one-seventh as long again), and the posterior part of the cell of hindwing is considerably less produced, vein 5 arising near the cell-spot.

Note.—I use the name *Larentia* Frietschke for *Xanthorhoe*. Section 2 of Turner (Proc. Roy. Soc. Victoria, xvi, new series, p. 274): "hindwings with vein 5 from below centre of discocellular, which is angled."

Here belong of New Zealand species—*L. semifissata* Walk., *chlamydota* Meyr., *beata* Butl., *semisignata* Walk., *farinata* Warr., and doubtless a few that I cannot at the present moment compare.

ABSTRACTS.

1. **Marine Algae from the Kermadecs.** By A. and E. S. Gepp. (Journal of Botany, vol. 49, pp. 17–23; 1911.)

A list of marine *Algae* collected by Mr. R. B. Oliver on the Kermadec Islands in 1908. The Kermadecs are washed by oceanic currents from the north and south-west, the latter being the stronger. This is plainly reflected by the algal flora, which is principally New Zealand. The following is the complete list. The distribution of the species is enclosed in brackets.

Ulva Lactuca L. (general); *U. laetevirens* Aresh. (South Australia, Tasmania); *Enteromorpha compressa* Grev. (Atlantic and Pacific, both north and south); *Cladophora fusca* Martens (Borneo); *Vaucheria* sp.; *Caulerpa racemosa* var. *uvifera* Weber v. Bosse, *forma intermedia* W. v. B. (Indian and Pacific Oceans, West Indies); *Codium tomentosum* Stackh. (general); *Durvillea* sp.; *Hormosira Banksii* Dcne. (Australia, Tasmania, New Zeland); *Carpophyllum maschalocarpum* Grev. (New Zealand); *C. elongatum* comb. nov. = *Cystophora elongata* Dickie (New Zealand); *C. Phyllanthus* Hook and Harv. (New Zealand); *C. plumosum* J. Ag. (New Zealand); *Taonia australasica* J. Ag. (Victoria); *Gymnosorus nigrescens* J. Ag. (North, South, and West Australia); *Dictyota prolificans* A. and E. S. Gepp (New South Wales and Queensland); *Sargassum fissifolium* J. Ag. (Queensland); *Chantransia* sp.; *Galaxaura* sp.; *Zanardinia marginata* J. Ag. (North and South Atlantic, North and South Pacific, Indian Ocean); *Gelidium longipes* J. Ag. (New Zealand); *Pterocladia capillacea* Born. (Atlantic, Mediterranean, Cape of Good Hope, Indian Ocean, China, Japan, Australasia); *Gracilaria confervoides* J. Ag. (Atlantic, Pacific, and Indian Oceans); *Laurencia Forsteri* J. Ag.? (South and West Australia); *Plocamium brachiocarpum* Kütz (New Zealand); *Martensia elegans* Her. (South Africa, West Australia, New South Wales); *Nitophyllum decumbens* (New Zealand); *Delisea pulchra* Mont. (Eastern Australia, Tasmania, New Zealand); *Asparagopsis Sandfordiana* Harv. (Western Australia and Queensland); *Euzoniella incisa* Falk. (South-west Australia, Tasmania, New Zealand); *Spongoclomium Brownianum* De Toni (West Australia); *Peyssonnellia rubra* J. Ag. (Adriatic, Polynesia); *Melobesia* sp.; *Amphiroa anceps* Dcne. (Norfolk Island); *Cheilosporum elegans* Aresch. (New Zealand, New South Wales); *Corallina officinalis L.* (general); *Corallina* sp.; *C. Cuvieri* Lamx. (South Australia, Tasmania).

L. C.

2. **Fructification of Macrocystis.** By E. J. Hoffman. (Univ. of California Publications in Botany, vol. 4, pp. 151–158, pl. 1; 1911.)

A quite different result is arrived at to that of Smith and Whiting, for the specimens examined show that the sorus is not confined to the newly formed bladderless leaves alone, and also that the reproductive bodies appear in continuous instead of disconnected layers only in the furrows of the leaves. It is suggested that the authors named above worked with an entirely different species.

L. C.

3. **Studies in Ornamental Trees and Shrubs.** By H. M. Hall. (Univ. of California Publications in Botany, vol. 4, pp. 1–71, pls. 1–11; 1910.)

An account with descriptions and remarks of a number of exotic ornamental trees and shrubs cultivated in California. The following are the New Zealand species: *Pittosporum tenuifolium*, *P. crassifolium*, *P. Ralphii*, *P. eugenioides*, *Leptospermum scoparium*, *L. ericoides*, *Metrosideros robusta*, *M. tomentosa*.

A yellow-flowered form of *Pittosporum tenuifolium* has appeared at Berkeley, growing in a row of normal black-flowered plants. This form is unknown in New Zealand, but according to Cheeseman yellow-flowered forms are known in other dark-flowered species.

L. C.

4. Die Geographie der Farne. By H. Christ. Pp. 357, figs. 130 (mostly from original photographs), and 3 maps. Gustav Fischer, Leipzig; 1910.

This work, from the hand of a most eminent pteridologist, is obviously of special interest to New Zealand biologists. It is divided into a general introduction and two parts, the first (pp. 9–136) being ecological, and the second (pp. 139–333) floristic. There is also a bibliography, which does not aim at completeness, of 182 titles arranged according to the various fern floras and their divisions, together with those dealing with general plant-geography, general works on ferns, and studies on special ferns and groups. The illustrations show both individual plants and fern-associations. Fig. 124, entitled *Leptopteris superba*, taken by Cockayne, is really *Polystichum vestitum*, and the locality is not Stewart Island, but forest at base of Big Ben, Canterbury.

In the introduction it is pointed out that the general impression that ferns, through ease of distribution by their spores, are more readily spread than flowering-plants, and have a wider distribution, is not the case. Thirty years' study of fern material from all over the globe has convinced the author that, in general, the distribution of ferns goes parallel with that of phanerogams. Where endemism is strong for the latter, so too is it with the accompanying ferns.

The ecological section is brimful of interest for New Zealand botanists, and requires close attention; a brief summary would be of no value. Many New Zealand species and genera are mentioned, while the ferns of other regions frequently exhibit parallel structure. Ferns, as a whole, are considered mesothermous hygrophytes and xerophytes.

Part II, dealing with fern floras, concerns students of bio-geography in general. Certain fundamental principles and matters are first explained—*e.g.*, endemism, which may be recent or ancient, as in the case of the New Zealand *Loxsoma*, with its sole relatives two species of *Loxsomopsis* of Central and South America; numerical relation of ferns to seed-plants in the different floral regions, and amongst other details it is shown that out of the 149 genera of ferns only thirty-three do not occur in the tropical forest-region, and of these *Doodia*, *Loxsoma*, *Leptopteris*, and *Todea* are confined to the South Temperate Zone; the fern-areas, which are, on the whole, more extensive than those of phanerogams, but yet a similar local endemism occurs in both classes; the cosmopolitan ferns, of which there are twelve well-defined (though it may be polymorphic) species, which occur with a few trifling exceptions over the whole globe*; pantropic ferns; the northern circumpolar extension of ferns, the author being of opinion that a backward current of species is moving northwards from a Tertiary haven of refuge for the forest-ferns in South China, the basal Himalayas, and Mexico; the arctic-alpine element, together with relics from the glacial period, but these are much fewer than are the flowering-plants of that character; and, finally, discontinuous areas of distribution, of which the following examples concern New Zealand: *Blechnum Fraseri* (New Zealand and Philippines), *B. Patersoni*, *Gleichenia dicarpa*, and other ferns of the Australasian flora, which, in common with the phanerogams, *Spinifex*, *Melaleuca*, and *Casuarina*, extend to the mountains or the strand of Malaya, and *Todea barbara* of New Zealand, Australia, and South Africa.

The distribution of certain genera is considered in detail: that of *Ophioglossum*, *Botrychium*, and *Gleichenia* alone concerns New Zealand. The forms of *Ophioglossum* are ill equipped for wide distribution, since they spread rather by a feeble vegetative increase than by their scanty spores. Their universal but quite local occurrence—for they are frequently isolated by wide tracts—together with their small amount of variation, is, according to the author, the greatest puzzle in the geography of ferns. In the far south of Australia and New Zealand, and in Argentina, South Chile, and Patagonia, the little northern species *Botrychium lunaria* occurs—an arctic footstep in the subantarctic! Between *Ophioglossum* and *Botrychium* a fundamental distinction exists, the former being tropical-cosmopolitan,

* The following are absent in New Zealand: *Adiantum capillus veneris*, *Pteris cretica*, *Dryopteris filix-mas*, *Osmunda regalis*.

but also mesothermous, and the latter boreal, but endowed with a strong power of expansion. *Gleichenia* is abundant in Tertiary rocks of Europe in its subgenera *Mertensia* and *Eugleichenia*, but the ice age drove it far to the south. The retreat of a Tertiary genus into the far oceanic south, with its insular climate, and into the tropical mountains, is most remarkable.

The author divides the earth, so far as ferns are concerned, into twelve floral regions, of which the Australian - New Zealand is one. The latter includes the rain-forest region of eastern Australia, Tasmania, and New Zealand. Central Australia is of no moment for ferns, and northern Australia comes into the Malayan region. The boundary between the two fern floras extends from King Sound along the north coast to the east coast, and thence through Queensland to the tropic of Capricorn, beyond which, southwards, the Malayan element gradually fades away.

As for New Zealand, to quote the author's words, "The fern-world is not only one of the most luxuriant and largest, but floristically one of the most interesting. It is a little world of ferns in itself, where almost all the genera of tropical and temperate ferns are to be found." A brief review of the species and genera is given, and their most important growth-forms; the presence of an endemic species of the tropical genus *Lygodium* is considered very remarkable. The author concludes: "It would be profitable to stay longer with this magnificent flora, which, though it is not the expression of a maximum hygrothermous forest climate, is easily the ideal fern climate of the present day, and plainly shows the optimum average conditions for the well-being of ferns."

The interesting question of the circumpolar extension of the Australian-New Zealand fern flora is discussed. The special group which may, in a certain sense, be called "antarctic" is not at all of a boreal-arctic character, but rather of a temperate to a subtropical character. Neither are the species analogous with either arctic phanerogams or even antarctic with the highly characteristic cushion form of these latter. First come six species of *Blechnum*, two of *Polystichum*, two of *Polypodium*, *Hymenophyllum ferrugineum*, *Asplenium obtusatum*, and *Schizaea fistulosa*. Also *Todaea* comes here, with its distribution in Australia, New Zealand, and South Africa. All the above are common to Australia - New Zealand, South America with Juan Fernandez, and in part South Africa. *Hypolepis rugulosa* may be also included (New Zealand, Reunion, Tristan d'Acunha, St. Helena, Juan Fernandez). The genus *Dicksonia* in closely related species extends from the Australasian floral region to oceanic Malaya, Juan Fernandez, and St. Helena. Then there is *Schizaea*, the most scattered, however, of all these genera.

The distribution of the above species may be explained on the supposition of a Tertiary or yet older region lying in the far south, whence they, in common with so many flowering-plants of the same area, extended radially. That the region in question was both ancient and warm is proved by the frondose structure and stems of the larger and the delicacy of the smaller ferns, *Schizaea* of *Juncus* form excepted. This element is a relic of a more extensive southern flora which dates from the Tertiary, or earlier, and which now remains on its small New Zealand-Australian area, thanks to the climatic conditions persisting that it requires. Further, in discussing the origin of the antarctic element of the south Chilian flora the author brings more facts in favour of an antarctic Tertiary centre of distribution, which is supported, moreover, by the additional fact of the presence of several Tertiary fossil ferns from Seymour Island which are related to, if not identical in some cases with, South American species.

L. C.

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5. **Die Gattung Acaena.** By G. Bitter. (Bibliotheca Botanica, Heft 71. pp. 336, pl. 38, figs. 98. Stüttgart, 1910–11.)

This voluminous and most painstaking work consists of two parts, the one general and introductory, and the other systematic and floristic. The author has not confined his studies to herbarium material of wild plants, but has searchingly examined the garden forms of Europe, especially those cultivated in the Bremen Botanical Garden, of which he is the director. These horticultural studies have led to the important discovery, first, of undoubted hybrids, and, secondly, of two cases of mutation. The first of these mutants arose from *Acaena ovalifolia* R. and Pav. in the botanic garden of Christiania, and the plant is described as subsp. *glabricaulis;* the second originated in the botanic garden of Bremen itself from a plant of *A. sericea* Jacq. f. var. *gracilis* Bitter, which had been in cultivation for many years.

Chapter II deals with the principles of a natural arrangement of the species within the genus, and in Chapter III the importance of the different forms of hairs is considered from both the taxonomic and ecological standpoints. Chapter IV deals with seedling forms, those of six New Zealand members of the genus being described at length. The occurrence of long, many-celled, thin-walled hairs in certain early seedlings, but which are absent in the adults, is noted as requiring special investigation.

Chapter V deals with the plant-geography of the genus. The question as to whether it is primarily subantarctic or the contrary is discussed, and, on the assumption that certain characters are older than others, a plea is established for a northern rather than a southern origin. But, on the other hand, it is shown how the present extensive occurrence of species not only in subantarctic South America, but throughout the subantarctic zone as a whole, together with New Zealand and parts of Australia, supports the theory of a southern origin.

Certain cases of discontinuous distribution are cited, especially that of the section *Acrobyssinoideae*, one species of which *A. tasmanica* Bitter, is endemic in Tasmania, but all the other species occur in the Chilian Andes from lat. 39·5° south to Cape Horn and South Georgia. *A. californica* Bitter, endemic in California, belongs to a section not otherwise extending north of central Chile and Patagonia.

The occurrence of local forms is much commoner than has been thought hitherto, especially on the isolated subantarctic islands. This discounts considerably the general view that the supposed wide area of certain species was due to carriage of the fruits with their hooked barbs by birds. At the same time, the author considers the occurrence of closely related species in distant localities due to bird-carriage, and cites a Sandwich Island species, with its close relatives in south and central Chile, and the *Acrobyssinoideae* of the Magellan region and Tasmania, but absent in New Zealand. But such distribution was not frequent enough to hinder the evolution of many local forms.

It is a remarkable fact that the New Zealand species of *Acaena* possess the following peculiarities not present in members of the genus elsewhere: (1.) A stunted habit of growth, although their foreign allies are robust and large-leaved—as, *e.g.*, the New Zealand forms of the polymorphic *A. Sanguisorbae* Vahl as compared with the Australian, and the three new species formerly referred to *A. adscendens* Vahl in New Zealand in comparison with the true species of that name and *A. laevigata* (Ait.) Bitter of South America. Nor can the alpine climate be responsible for the marked exhibition of this growth-form in the endemic New Zealand section *Microphyllae*, since the Chilian Andean species show no such character. (2.) The brownish colour of the leaves in certain varieties of the *Sanguisorbae* group and in *A. microphylla* Hook. f., and such colouring is present in members of other families of New Zealand alpine plants. Grey-coloured leaves, arising either through a covering of wax or through air-spaces between the cells, is another characteristic, but there are Chilian examples of similar phenomena.

It would serve no purpose to draw up a synopsis of the author's arrangement of the New Zealand species. A really critical study of his work is demanded on this point. Here only some general conclusions are noted regarding the limitations of species, important alterations, and so on.

First, it must be pointed out that a most comprehensive view is taken as to the species themselves, so that the polymorphic species are groups which do not exist at all as true entities. These species are subdivided into smaller but still comprehensive groups as subspecies, these into varieties which are the true entities of the flora, and these occasionally into forms.

A subspecies of *A. ovina* A. Cunn. is created called *nanella* Bitter, based on specimens sent by Cockayne to Berlin as introduced and collected on the Canterbury Plains, the author considering the stunted habit of specific importance.

Acaena adscendens Vahl, hitherto supposed to extend to New Zealand, is restricted to plants of the Magellan region and Kerguelenland, while the New Zealand forms referred to *A. adscendens* are treated by the author as *three* distinct species—*A. saccaticupula* Bitter, *A. hirsutula* Bitter, and *A. fissistipula* Bitter, the two latter being closely related, but the former coming into a different subsection allied to that containing *A. adscendens*. Varieties are also described of all three species.

Acaena Sanguisorbae Vahl is restricted to Australian, Tasmanian, and New Zealand plants, the Tristan d'Acunha plant being referred to *A. sarmentosa* Carmichael and considered as restricted to that group, while the New Amsterdam plant is referred to *A. insularis* Citerne.

Eight subspecies of *A. Sanguisorbae* are created for the Australian and Tasmanian forms, none of which extend to New Zealand. The New Zealand forms, all of which are endemic, consist of the following subspecies :—

1. *Novae-Zelandiae* (Kirk) Bitter, and its varieties—*viridissima* Bitt. and *subtusglaucescens* Bitt.
2. *Caesioglauca* Bitter (probably = var. *pilosa* T. Kirk of *A. Sanguisorbae*) and its vars. *brevibracheata* Bitt. and *involucrata* Bitt.
3. *Profundeincisa* (described from cultivated plants) and its variety *sericeinitens* Bitt. (Kelly's Hill, leg. L. Cockayne).
4. *Pusilla* (described from a cultivated plant in the Bremen Botanical Garden) and its five varieties, three of which are founded on specimens in Herb. Berol., collected by Krull in Chatham Islands, and another var. *antarctica* Cockayne.
5. *Aucklandica** (Auckland Island, Hooker. f. Herb. Berol., Florent., Paris).

The remainder of the New Zealand species are put into two special sections of the genus, both of which are endemic, *A. glabra* Buchanan forming the section *pteracaena* Bitter, and *A. microphylla* Hook f. and *A. Buchanani* Hook f. the section *microphyllae* Bitter. *A. microphylla* is divided into the subspecies *eumicrophylla* Bitt. and *obscurasens* Bitt. The former contains the var. *inermis* (Hook. f.) Kirk, and this is resolved into two forms named respectively *longiscapa* Bitt. and *breviscapa* Bitt. and the var. *pallideolivacea* Bitt. described from a cultivated plant in the Berlin Botanic Garden. The subspecies *obscurascens* is based on cultivated plants coming from the nursery of Thomas Ware; the vars. *depressa* T. Kirk and *pauciglochidiata* Bitt. are included here. This latter is evidently the dune form of Southland. A new variety *inermis* Bitt. of *A. Buchanani* is described.

Finally, a number of hybrids of garden origin, mostly between New Zealand species, especially *A. microphylla* and *A. Sanguisorbae* are described and their leaves figured.

It must be added that the author does not look upon this work as a monograph of the genus, but only as material for such.

L. C.

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6. On the Peopling by Plants of the Subalpine River-bed of the Rakaia (Southern Alps of New Zealand). By L. Cockayne. (Trans. and Proc. Bot. Soc. Edin., vol. 24, pp. 104–125, pl. 3; 1911.)

The relation between the evolution of a land form and its plant covering is a matter of high phyto-geographical interest, but one extremely difficult to estimate in the majority of cases. A New Zealand stony river-bed affords an excellent subject for such a study. The peopling of such near its glacier source may be a similar phenomenon to what happened on the Canterbury Plains at the close of the glacial period. A brief account is given of the physiography of a river-bed, and it is shown to be in a constant state of change, and to present all gradations of station from new stony bed, swept at times by water, to low stable terraces. The river-bed in question is in a forest climate depending upon the average distance reached by the western rainfall. Generally speaking, the climate is partly hygrophytic and partly xerophytic, for the effect of the heavy rain is neutralized by the insolation, the frost, and, above all, the high winds. An important factor affecting the soil is the presence, at no great distance below the surface, of ice-cold water. A glacial river-bed near its source is both a physically and physiologically dry station.

A synopsis is given of the species of the river-bed according to their growth forms. There are two low trees, fourteen shrubs, two lianes, and thirty herbs or subshrubs. A special account is furnished of the *Raoulia* form, and it is pointed out how the species show an epharmonic gradation of forms from the rapidly growing mats of *R. tenuicaulis*, with its open mesophytic leaves of seedlings and reversion shoots, to the highly differentiated woolly masses of *R. eximia*, &c. The

[* It is almost certain that this is identical with *A. Sanguisorbae* var. *antarctica* Cockayne. That variety was founded, so far as the description of the flower and scape went, upon one flower coming out of season on a plant just brought from Auckland Island. It is now known that the fruiting-scape is much longer than as described, and that its hairiness was underestimated. Bitter suggests the Auckland Island plant may be related to *A. insularis*.]

peopling of the bed resolves itself into several distinct stages, each of which is really a valid plant association always present on the river-bed, and although, like any so-called stable plant formation, it is capable of change, it is just as much a feature of the landscape as is a forest. The first stage on the unstable bed is an *Epilobium* association consisting of certain species of that genus and 2–3 species of *Raoulia*. The second stage is a *Raoulia* association, which denotes more stable ground. Here the low cushions of *R. Haastii* become dominant. They offer a soil for various steppe-plants, which in time kill and replace them, and by degrees steppe, the third stage, is established through tussock-grasses becoming dominant. In some places, where the conditions are favourable, scrub is the climax association. The affinities of the river-bed associations are dealt with. Prior to its peopling it is nearest allied to shingle-slip, but they have no species in common, unless the shingle be fairly stable, as in the bed of a gully. The *Raoulia* association is ecologically and floristically related to lowland river-bed, though there *R. Haastii* is absent. The steppe is related to that of dry mountain-slopes, but is made up of fewer species. The scrub association is almost identical with subalpine scrub, and the *Discaria* thickets have their counterpart on lowland river-beds and dunes.

L. C.

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7. **The Hepatics of New Zealand.** By L. S. Gibbs. (Journal of Botany, vol. 49, pp. 261–266; 1911.)

A list of *Hepaticae* collected by the author in October and November, 1907, principally in the forest at Nihotapu and Te Aroha, Auckland. The identifications are by F. Stephani, of Leipzig. Details are given as to habitats and general distribution. Forty-one species are noted, of which *Marchantia lacriloba* Steph., *Aneura papulolimbata* Steph., *Calobryum Gibbsiae* Steph., and *Lepidozia Gibbsiana* Steph. are new, and will be described in due course. *Treubia insignis* Goebel, of Java, is considered identical with the New Zealand plant.

L. C.

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8. **Handbuch der Regionalen Geologie: New Zealand and Adjacent Islands.** By P. Marshall, M.A., D.Sc., F.G.S., &c. (Heidelberg, 1911.)

This work, one of a series being published in Germany in order to give in handy form a reliable account of the geology of each country of the world, contains an excellent and concise summary of what is known up to the present of the geology of New Zealand. The subject is treated in a judicial and admirable manner, with copious references to authorities and a careful regard for the opinions of those differing from the author's own. No further reference need be made in this abstract to those parts of the work which summarize the results of previous workers, and only such points will be dealt with as introduce new matter or have bearing on the author's departure from accepted opinions on the difficult questions of New Zealand geology.

The most important point to which reference must be made is the application of the term "Oamaru system" to all the beds of Tertiary age below the Pliocene. The author here follows the classification suggested in his paper on the "Younger Rock-series of New Zealand," published in last year's Transactions, and includes in one conformable series beds which are generally assigned to the Waipara, Oamaru, and Pareora systems.

The rocks usually classified as Maitai, together with those admitted by all experienced authorities to be of Triassic and Jurassic age, are also included in one conformable series and called Jura-Trias. The conclusion has been arrived at by the author after a careful examination of the beds in the typical locality near Nelson, where rocks containing characteristic Triassic fossils are said to be conformable to those of the Maitai series, which are identical with those forming the main mountain masses of New Zealand. This point of view is not by any means a new one, since several observers have expressed their belief in the conformity of

the Triassic beds near Nelson to the typical Maitai series, although they have frequently changed their attitude on the question. The author makes a radical departure, however, in assigning to this series the schists of the Pelorus Valley and the Marlborough Sounds as well as those of Central Otago. He says, "It is therefore true that, so far as observations go, no unconformities of any importance have yet been discovered between the Trias-Jura and the schists of Otago, though the two formations extend side by side for 200 miles. . . . Such remarkably concordant observations show that the stratigraphical evidence almost compels one to place the Trias-Jura and the Otago schists in the same series." Lithological evidence to support this contention is cited from Otago, and also from the schist-areas of Westland. The author points out the entire absence of fragments of schists in the conglomerates and sandstones of which the Maitai sediments are formed, although fragments of granite and other plutonic rocks are common. The palaeontological evidence, as well, is considered favourable to the contention that the sediments, and therefore in all probability the conformable metamorphic rocks, are of Trias-Jura age.

Section III of the work deals with the geological history of the country, and the special conditions under which the beds were laid down. The author is of the opinion that the thick Maitai series was laid down on a shore-line, and not in the deep sea as believed by Hutton. He explains the absence of fossils by comparing the conditions of deposition with those of a modern sandy-shore line, which is almost devoid of animal-remains.

The problems connected with the orogeny of the country are fully dealt with, and reference is made to the bearing of the recent work of the Geological Survey on this important question. The author dissents from the view insisted on by Gregory that there are two periods of mountain-folding in New Zealand, one trending north-west and the other north-east, the former occurring in north-west Nelson and in Otago. It is pointed out that in the latter case the rocks of undoubted Jurassic age are affected by this direction of folding in Otago, and therefore the folding cannot be of earlier date, it being in all probability of late Jurassic age.

The author deals briefly in various sections with the inferences that can be drawn from the character of the fauna and flora as to the climates of former geological periods. He apparently accepts Ettingshausen's determinations of our fossil plants. Perhaps, in the absence of published papers showing the extremely doubtful value of the identifications, the author was compelled to do so. However, the seeds identified as hakea, occurring in the lignites of Central Otago, should be assigned to a *Podocarpus* allied to *P. vitensis*, which suggests as equally interesting problems of land connection or the transport of seeds as if the relation was really with an Australian form.

Full attention is given as occasion demands to the history of the volcanoes in various parts of the country; the outlying islands to the south are specially referred to; and the difficult question of the Pleistocene glaciation receives careful consideration. These are sections of the subject on which the author is specially qualified by his own personal researches to speak with authority. A brief summary of the economic geology of the country is given, and the work concludes with a list of the literature which has appeared since Wilcken's catalogue was compiled in 1910, a list of the more important works dealing with New Zealand geology, and a list of the works cited in the text.

R. S.

John Mackay, Government Printer, Wellington.—1911.

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PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1911

PART III

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

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PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE.

1911.

PART III.

NINTH ANNUAL MEETING.

CHRISTCHURCH, 25TH JANUARY, 1912.

THE annual meeting of the Board of Governors was held at Canterbury College, Christchurch, on Thursday, 25th January, 1912, at 10 a.m.

Present: Mr. T. F. Cheeseman, President (in the chair), Messrs. M. Chapman, K.C., Dr. Cockayne, C. A. Ewen, A. Hamilton, H. Hill, H. Hesse, Dr. Hilgendorf, Professor Kirk, Professor Marshall, Dr. Petrie, R. Speight, J. Stewart, G. M. Thomson, M.P., and K. Wilson.

Dr. Cockayne welcomed the Governors to Christchurch, and the President replied.

The Secretary announced the changes in the representation on the Board, and the incorporation of the Wanganui Philosophical Society, and called the roll.

Wanganui Philosophical Society.—The President moved, That the action of the Standing Committee in incorporating the Wanganui Philosophical Society be confirmed; that the Board of Governors offers its sincere congratulations to the new Society, and tenders its best wishes for its future success. The motion was seconded by Mr. Hamilton, and carried.

Apologies.—The President apologized for the absence of the Hon. the Minister of Internal Affairs (Mr. Buddo), and for Mr. John Young.

Presidential Address.—The President then delivered his annual address (see page 75). He moved a resolution of condolence to the late Sir Joseph Hooker's family, which was seconded by Dr. Cockayne, and carried, as follows:—

The Board of Governors of the New Zealand Institute is desirous of recording, at the earliest opportunity, its sincere and profound regret at the death of Sir Joseph Dalton Hooker, for many years one of the leaders of botanical science, the co-worker of Darwin, of Lyall, and of Bentham; and renowned as an explorer, an author, and an administrator.

His researches into the botany of New Zealand, commenced during the Antarctic voyages of Sir J. D. Ross, continued during the preparation of the "Flora Novæ Zelandiæ," and culminating in the publication of the "Handbook of the New Zealand Flora," have been of incalculable value to science in New Zealand, and have placed the study of its botany on a secure and lasting foundation, while the encouragement and assistance which he invariably gave to all students and investigators have been of the utmost service to those who have endeavoured to supplement his work.

The Board also desires that a copy of this resolution should be sent to Sir Joseph Hooker's family, with an expression of its sincere condolence, and an assurance of its sympathy in their sad bereavement.

Correspondence.—Letters from Dr. W. S. Bruce (21st September, 1911) acknowledging his election as honorary member, and from Hon. D. Buddo (3rd May, 1911) with reference to bathymetrical and biological surveys, were received.

Incorporated Societies' Reports.—The annual reports of the Philosophical Institute of Canterbury, the Manawatu Philosophical Society, the Otago Institute, and the Wellington Philosophical Society were received.

Standing Committee, Annual Report.—The annual report of the Standing Committee was read and adopted, on the motion of Mr. Hamilton, seconded by Mr. Chapman. The report was as follows:—

Report of the Standing Committee.

Four meetings of the Standing Committee were held during the year, the attendance being as follows: Mr. Cheeseman, 4 meetings; Professor Easterfield, 4; Mr. Hamilton, 4; Mr. Chapman, 3; Mr. Ewen, 3; Mr. Young, 1.

Hector Memorial Fund.—A deed of trust has been prepared, and is submitted for approval of the Board. Award for 1911: The Committee of Award has forwarded its recommendation in a sealed envelope, to be opened at the annual meeting.

Hutton Memorial Fund (Medal).—Professor Benham, F.R.S., the first recipient of the award, was publicly presented with the medal on the 4th April, 1911, by the Chancellor of the Otago University, James Allen, Esq., M.P. The next award may be made in 1913.

Purchase of Back Numbers of the Transactions.—A number of volumes have been received in exchange, and the Secretary is now able to supply sets of Transactions from Vol. 5 at the reasonable price of £15. The Committee submits that the possibility of reducing the immense stock of back numbers should be considered.

Publications of the Institute.—Copies of Vol. 43 of the Transactions were, in accordance with the Act, laid on the table of the House of Representatives on the 11th August, and on the table of the Legislative Council on the 23rd August, 1911. This volume was posted simultaneously to all New Zealand members on the 17th August. The index to the first forty volumes of the Transactions of the Institute (1868–1907) was published in July, 1911. So far, only some twenty-five copies have been disposed of.

Finance.—The Standing Committee made an unsuccessful endeavour during the last session of Parliament to have the annual Government statutory subsidy of £500 increased. It is, however, hoped that a further effort in this direction which is to be made may be more successful. It will be necessary to consider methods for increasing the income of the Institute in order to enable its liabilities to be met. The following are suggested as some ways in which money may be obtained and saving effected: (1.) By the payment by every incorporated society of a portion of its income to the Institute, as provided by Regulation 5E under the New Zealand Institute Act, 1903. (2.) By exercising greater economy in the travelling-expenses of members of the Board. (3.) By holding all meetings in Wellington.* (4.) By ceasing the separate publications of the Proceedings. That the incorporated societies should subsidize the Institute is only fair, since each of their members receives the bound copy of the Transactions and Proceedings, and Regulation 5E states that a proportional contribution may be required from each society towards the cost of publishing it. The payment of the hotel expenses of members of the Board, and the holding of the annual meeting away from Wellington, are recent innovations, entailing much extra expense. If all the members of the Board attended it would cost, for personal

* This suggestion was pointed out by Dr. Hilgendorf as being contrary to section 8, New Zealand Institute Act, 1908.

expenses of members, £124 9s. 4d. to hold the annual meeting in Auckland, and only £50 19s. 10d. to hold it in Wellington. The separate publication of the Proceedings is an expensive experiment, of doubtful utility.

British Association Meeting in Australia, 1914.—Several gentlemen having approached the Government with a request that it should financially assist the movement to induce some of the British Association members and a selection of American and Canadian men of science to visit New Zealand, a promise to give £2,000 was made by the Right Hon. the Premier. A Reception Committee has been formed having the following constitution: (1) The original signatories of the letter to the Premier; (2) the representatives of the Professorial Boards of the New Zealand University Colleges; (3) the representatives of the New Zealand Institute branches; (4) the New Zealand Institute subcommittee and the Secretary of the New Zealand Institute. As a result of their Committee's efforts, an invitation from the New Zealand Government was, in September, 1911, cabled to the High Commissioner in London, who was instructed to associate himself with Professor E. Rutherford and Mr. W. P. Reeves in communicating the invitation to the British Association, then meeting at Portsmouth. The invitation was accordingly put before the officers of the British Association at the September meeting. While of the opinion that the invitation should be accepted with their grateful thanks, the officers, seeing that the members of the Association would not visit New Zealand until early in 1915, asked to be allowed to postpone consideration of the invitation until the beginning of 1914, when they will communicate their intentions to the High Commissioner for New Zealand. Professor Maclaurin has been asked to act as the agent of the Committee in America.

Position of the Incorporated Societies.—Mr. Hamilton has given notice to move the following resolution: "That the names of the Southland and Westland Societies be removed from the list of societies incorporated in the New Zealand Institute, unless cause to the contrary be shown at the annual general meeting, or within one month afterwards."

T. F. Cheeseman.

Return.—A return showing the cost of holding the annual meeting in Auckland compared with Wellington was received.

Government Statutory Grant.—It was proposed by Mr. Thomson, and seconded by Mr. Speight, That the Government be asked to amend the New Zealand Institute Act in the direction of increasing the annual statutory grant from £500 to £750; and, further, that it be asked to make a special grant for the current year of £250 to enable the Institute to meet its outstanding liabilities.—Carried.

Proceedings.—It was proposed by Mr. Chapman, and seconded by Mr. Speight, That, in the event of the Government declining to increase the statutory grant to the Institute, the publication of the proceedings be discontinued.—Carried.

Southland and Westland Societies.—Mr. Hamilton moved, and Mr. Chapman seconded, That the names of the Southland and Westland Societies be removed from the list of societies incorporated in the New Zealand Institute, unless cause to the contrary be shown at the annual general meeting in 1913, or within one month afterwards.—Carried.

Future Reports.—It was proposed by Mr. Speight, and seconded by Mr. Thomson, That the Secretary be instructed to furnish each member of the Board with a copy of the report of the Standing Committee, and the business to be submitted at the meeting, one week previous to the meeting of the Board of Governors.—Carried.

Reports of Incorporated Societies.—Mr. Chapman proposed, and Dr. Petrie seconded, That the affiliated societies be requested to furnish the information required under the resolution of the Board of the 27th January, 1911.—Carried.

Statement of Receipts and Expenditure.—Mr. Hamilton moved, and Dr. Petrie seconded, That the audited statement of accounts be adopted.—Carried.

Professor Marshall proposed, and Dr. Hilgendorf seconded, That at future annual meetings of the Board of Governors a statement of assets and liabilities, duly audited, be added to the statement of receipts and expenditure.—Carried.

STATEMENT OF RECEIPTS AND EXPENDITURE.

Receipts.	£	s.	d.
Balance brought forward ..	77	11	2
Government grant	500	0	0
Sale of "Maori Art" ..	20	19	0
Sale of Transactions ..	23	2	0
Postage refund	1	18	0
Extra authors' reprints ..	6	0	7
Sale of index	5	5	3
Sale of Bulletins Nos. 1 and 2	0	4	6
	£635	0	6

Expenditure.	£	s.	d.
Salary, Secretary	25	0	0
Typing	13	8	2
Museum custodian services ..	5	0	0
Petty cash—			
Hon. Editor	5	0	0
Secretary	4	0	0
Bank commission and exchange	0	12	6
Compiling catalogue of New Zealand scientific literature	10	0	0
Postage, Proceedings ..	4	17	4
Postage, Transactions ..	20	8	0
Travelling-expenses of President	17	3	0
Insurance of books.. ..	9	0	0
Government Printer—			
Printing Proceedings—Part II, 1910; Part I, 1911	28	13	6
Printing authors' reprints..	2	7	0
Printing index to forty vols. Transactions	60	0	0
Compiling above index ..	30	0	0
Stationery	8	13	7
Book purchased for library ..	0	18	9
Balance as per pass-book ..	389	18	8
	£635	0	6

Carter Bequest, Hutton Memorial Fund, and Hector Memorial Fund Statements.—It was proposed by Mr. Hamilton, and seconded by Dr. Petrie, That the audited statements of the Carter Bequest, the Hector Memorial Fund, and the Hutton Memorial Fund be received.—Carried.

A letter from Dr. Chilton with reference to his grant from the Hutton Fund was received.

CARTER BEQUEST.—Statement of Account, 31st December, 1910, to 31st December, 1911.—Residuary Account.

Cr.	£	s.	d.
Balance as at 31st December, 1910	2,988	18	7
Interest, N.Z. Loan and Mercantile Agency Company	0	13	9
Interest, Public Trust Office	134	7	1
	£3,124	0	3

Dr.	£	s.	d.
Public Trust Office commission	0	0	4
Balance	3,123	19	11
	£3,124	0	3

HUTTON MEMORIAL RESEARCH FUND.—Statement of Account, 31st December, 1910, to 31st December, 1911.

Cr.	£	s.	d.
Balance as at 31st December, 1910	642	2	1
Public Trust Office, interest ..	28	8	9
	£670	10	10

Dr.	£	s.	d
Dr. C. Chilton, payment ..	10	0	0
Balance	660	10	10
	£670	10	10

HECTOR MEMORIAL FUND.—Statement of Account, 31st December, 1910, to 31st December, 1911.

Cr.	£	s.	d.	*Dr.*	£	s.	d.
Balance as at 31st December, 1910	444	7	10	Balance	1,130	12	1
Fixed deposits	619	4	0				
Interest	24	15	2				
Public Trust Office, interest	42	5	1				
	£1,130	12	1		£1,130	12	1

Coleoptera.—The President detailed the steps he had taken regarding the proposed publication of Major Broun's work on the *Coleoptera.*—Approved.

Hector Memorial Deed of Trust.—On the motion of Mr. Hamilton, seconded by Dr. Petrie, the President and Secretary were authorized to affix the seal of the Institute to the Hector Memorial trust deed. (See Appendix, page 106.)

Hector Medal Award.—The recommendation of the Award Committee, which was received in a sealed envelope, was then read, and it was unanimously resolved, That the recommendation of the Hector Medal Committee, which recommended that the Hector Medal be awarded to Dr. Cockayne, be adopted.

Publication Committee Report.—This was read, and, on the motion of Mr. R. Speight, seconded by Mr. A. Hamilton, it was resolved, That the report of the Publication Committee be received. The report was as follows:—

REPORT OF PUBLICATION COMMITTEE.

The Committee begs to report that during the year sixty-nine papers in all were sent in for publication in the Transactions and Proceedings; these were duly considered by the Committee, and were dealt with as follows: Six were published in the Proceedings—*i.e.*, one in Part I, two in Part II, and two in Part III; one lengthy paper was reserved for separate publication; three papers were not recommended for publication; the remainder were published in the Transactions as fifty-seven papers, in three cases two papers dealing in each case with the same subject having been combined under one title. Notwithstanding that many of the papers were considerably cut down at the request of the Committee, both as regards text and illustrations, Vol. 43 of the Transactions proved to be rather larger than in the previous year, filling 680 pages, with 32 plates and a very large number of text figures. The Transactions were issued on the 1st July, 1911; the first part of the Proceedings, pages 1 to 30, was issued on the 10th September, 1910; the second part, pages 31 to 58, on the 18th January, 1911; and the third part, pages 59 to 128, on the 12th May, 1911.

The Committee regrets that, owing to financial reasons, it has not yet been found possible to print the paper that was reserved for separate publication.

In accordance with the resolution passed at the annual meeting of the Board of Governors in January, 1911, approving of the policy of printing short scientific papers in the Proceedings, six papers were printed in the Proceedings, 1911, Part I; this part, comprising 33 pages, was issued on the 30th August, 1911. Part II is now in the Printer's hands, and in it two short papers are being published.

The Committee desires to emphasize again the desirability of having the scale of charges for authors' reprints definitely fixed and printed, so that the probable cost of additional copies may be readily obtainable. This step was considered and approved by the last meeting of the Board of Governors, but up to the present no schedule of charges has been furnished.

With a view to diminishing the cost of the Transactions without interfering with its value as a scientific publication, the Committee wishes to affirm the principle that the use of photographs, unless of excellent character, should be discouraged, unless they serve to illustrate more satisfactorily the features which the author

desires to draw attention to. Even moderately executed drawings are at times more explanatory from a scientific point of view than a good photograph.

The Committee would also like to recommend, unless the matter is out of its province, that a list of publications actually received by the Institute should be inserted in the Transactions in addition to the list of the societies, &c., to which the Transactions are sent free of charge. This would give at times important information as to the presence in New Zealand of papers that are of value to workers in many branches of science.

The Committee would also recommend that theses written for honours degrees should be pruned of all superfluous matter before being published in the Transactions. Maps and sections coloured as suitable for examination purposes should be redrawn in a form and character adapted for printing in the Transactions, and the Secretaries of societies should see to this before accepting them for transmission to the Editor.

In October Dr. Chilton resigned from his position as Honorary Editor, as he was about to visit Europe, and, with the approval of the President, the Publication Committee arranged with Mr. R. Speight to act as Honorary Editor till the annual meeting of the Board of Governors in January.

R. Speight, Acting Hon. Editor.

Hon. Librarian's Report.—The report of the Hon. Librarian was received, as follows:—

Hon. Librarian's Report.

I have to report that very little has taken place in regard to the library during the last year.

The usual exchanges have been received and noted.

Additional pigeon-holes have been provided for the better storage of some of the serial publications.

Very little use has been made of the library, except by one or two college students.

I have again to regret that it seems impossible to have this collection of books properly attended to. It needs the constant care and attention of a qualified librarian, and the position will always be unsatisfactory until this is arranged for.

A. Hamilton, Librarian.

Exchange List Committee.—The report of the Exchange List Committee was received, and, on the motion of Mr. Chapman, seconded by Mr. Wilson, it was resolved, That the B list of the Exchange Committee's report be referred to the Standing Committee to act on the recommendations of the Exchange Committee. The report of the Committee was as follows:—

Exchange List Committee Report.

The Committee on Exchanges reports that it drew up an interim report, a copy of which was printed and sent out to each of the members for their detailed consideration.

The societies, &c., who send or receive publications were classed under the following heads:—

A. Societies to whom the New Zealand Institute publications are sent, and from whom publications are received regularly.

B. List of societies to whom the publications of the New Zealand Institute are sent, but which either do not publish Proceedings and Transactions or do not send them in exchange.

C. List of societies who send publications of various kinds at irregular intervals, but who do not receive the publications of the New Zealand Institute.

The Committee was asked to make suggestions on these three lists, and in order to assist it in the consideration of the matter further lists were added.

D. List of publications received by the Museum in exchange for the Museum Bulletin.

E. List of those societies which in exchange for the Transactions of the New Zealand Institute send more than one copy of their publications to the library of the New Zealand Institute or other libraries of the branches.

F. List of publications subscribed by the Wellington Philosophical Society.

These three lists were simply included to point out what literature was available in Wellington, as it was understood that, although the publications in the D and F lists are not the property of the Institute, the members of the Institute are at liberty to borrow them for consultation.

It was also thought that a list of those works which are available would prevent perhaps unnecessary duplication again.

The general feeling of the Committee appears to be that those societies on the B list, with few exceptions, should be struck off the list of those to whom the publications of the Institute are sent, it being understood that if they still desire to receive our publications they should state what publications of their own they are willing to send in regular exchange.

Your Committee therefore suggests that during the current year the matter should be taken in hand, and a notice sent explaining why the current volume is not forwarded as usual.

Your Committee hopes that during the present year some steps may be taken to reorganize the library under a permanent librarian, who shall devote more time to its proper custody and arrangement than is possible at the present time.

For the Committee (Professor Easterfield and Mr. Hamilton).

A. Hamilton.

Committee to formulate Regulations.—The report of the Committee was received, and, on the motion of Mr. Hamilton, seconded by Mr. Hesse, it was resolved, That the regulation relating to the adoption of the seal be gazetted. The report was as follows:—

Committee to formulate the Regulations.

Your Committee has considered the various regulations passed by the Standing Committee since the annual meeting, 1904, a copy of which is annexed.

Mr. Chapman has kindly gone through the whole of the regulations or resolutions very carefully, and finds that the only one, in his opinion, that requires to be gazetted as a regulation in accordance with the Act is the one relating to the readoption of the old seal of the former Institute as the seal of the Institute under the new Act.

There are a few others: No. 5, Travelling-expenses of Governors to be paid; No. 6, The money of the Carter Bequest to be placed in the hands of the Public Trustee as trustee for the Institute; No. 14, That it is not competent for members (*sic*) of the Board to hold any paid office under the Board; No. 19, That a certain number (say, ten) of separate copies of papers be printed for the Institute in addition to the copies supplied to the author; and No. 20, That the Editor be the convener of the Publication Committee. These might, without any harm, be made regulations by the Institute in a formal manner, and might then be gazetted.

It is not considered necessary that the other resolutions be gazetted as regulations.

For the Committee (Messrs. A. Hamilton, M. Chapman, T. F. Cheeseman, and Dr. Chilton). A. Hamilton.

Hector Medal Committee.—The report of the Committee to obtain the Hector Memorial Medal was received, as follows:—

Report of Committee to obtain the Hector Medal.

The Committee beg to report that they have communicated with Messrs. Wyon, and instructed them to proceed with the designing of the Hector Medal in accordance with suggestions forwarded by the Committee.

Messrs. Wyon, when the design was ready, were to submit it for approval to Sir Edward Thorpe.

Subsequent correspondence shows that this has been done, and your Committee have every hope that a copy of the medal will be ready to lay before the Board of Governors at the annual meeting.

For the Committee (Mr. A. Hamilton and Professor Easterfield).

A. Hamilton.

British Association Reception Committee.—The report of the Committee was received, as follows:—

Report of Committee to deal with Australian Visit of the British Association for the Advancement of Science.

Your Committee have met and drawn up lists of American scientific men whom it would be desirable to invite to New Zealand to attend a gathering of the members of the British Association for the Advancement of Science.

The formal invitation to the members of the British Association was communicated to the Council by the High Commissioner for New Zealand in September.

A letter has been received from the High Commissioner stating that they were pleased to receive the invitation, but that they consider it too soon to make any definite arrangements in the matter.

For the Committee (Messrs. T. F. Cheeseman, A. Hamilton, and Professor Easterfield).

A. Hamilton.

Fishes of New Zealand.—On the motion of Mr. Thomson, seconded by Professor H. B. Kirk, it was resolved, That the Board of Governors of the New Zealand Institute recommend to the Government the desirability of having a full and illustrated catalogue of the fishes of New Zealand prepared and printed.

Scientific Board of Advice.—It was proposed by Mr. Thomson, seconded by Mr. Hamilton, That this Board recommend to the Government—(1) That a Scientific Board of Advice be formed to which the publication of all scientific work should be referred; (2) that it be suggested that the Board consist of a Minister (*ex officio*), three scientific representatives of the Government Departments nominated by the Governor, and three members elected by the Board of Governors of the New Zealand Institute; (3) that special grants for all publications to be issued (except those of the New Zealand Institute) should be made by the Government.—Carried.

Office for the Institute.—It was proposed by Mr. Hamilton, seconded by Mr. Hill, That the Minister of Internal Affairs be asked to request the Government to provide in the new building for the National Museum accommodation for the library and offices of the New Zealand Institute, and also to provide storage-room for copies of the Transactions and papers of the Institute. The Institute also desires that there should be a suitable room in the building, which they might use as a lecture-room, to accommodate one or two hundred persons.—Carried.

Election of Officers for 1912.—President, Mr. T. F. Cheeseman; Hon. Treasurer, Mr. C. A. Ewen; Joint Hon. Editors, Mr. R. Speight and Dr. Hilgendorf; Publication Committee, Professors Benham and Chilton, Dr. Hilgendorf, Mr. Speight, and Mr. G. M. Thomson; Secretary, Mr. B. C. Aston.

Date and Place of Meeting.—On the motion of Mr. Thomson, seconded by Mr. Speight, it was resolved, That the next annual meeting be held on Wednesday, 29th January, 1913; and, on the motion of Mr. Hill, seconded by Dr. Petrie, it was resolved that it be held in Wellington.

Hector Award Committee.—On the motion of Mr. Speight, seconded by Dr. Hilgendorf, it was resolved, That the Committee for the award of the Hector Medal for the year 1913 be Professors F. D. Brown, Evans, Orme Masson, and Mr. G. M. Thomson.

Travelling-expenses of Governors.—On the motion of Mr. A. Hamilton, seconded by Mr. Hesse, it was resolved, That the usual expenses be paid to Governors and officers attending this meeting.

Votes of Thanks.—It was resolved that hearty votes of thanks be accorded to Dr. Chilton and Mr. R. Speight for acting as Editors of the Transactions and Proceedings of the Institute; to the Canterbury College for the use of their Board-room; to the Canterbury Philosophical Institute for their generous hospitality.

T. F. Cheeseman.

Read and confirmed.
26th January, 1912.

PRESIDENTIAL ADDRESS.

The following is the presidential address delivered at the annual meeting of the Board of Governors of the New Zealand Institute at Christchurch, 28th January, 1912, by Mr. T. F. Cheeseman, F.L.S., F.Z.S., Curator of the Auckland Museum :—

Gentlemen of the Board of Governors,—It is clearly my first duty, as it is my sincere pleasure, to express my cordial thanks for the confidence you have shown in placing me in the responsible and honourable position of your President. And although I fear that this confidence is not so well founded as it should be, and although I am fully sensible of many shortcomings and deficiencies, I feel assured that I can rely on the cordial co-operation and support and the lenient judgment of the members of this Board. But for this belief I should indeed have hesitated before assuming duties and responsibilities for the discharge of which I possess no special qualifications.

Before proceeding to address you in reference to the work and progress of the Institute, it is my painful duty to advert for a few moments to the loss science has sustained through the death of Sir Joseph Dalton Hooker, the greatest of British botanists, the senior honorary member of this Institute, and the man who above all others has left the most enduring mark on the history of science in New Zealand. This is neither the time nor the place to offer a formal eulogy on one who for more than seventy years was an active worker in the field of botanical science, and whose contributions thereto are renowned throughout the whole world. All I can do here is to make some general remarks on his life and career, with special reference to their connection with New Zealand.

In 1839, Hooker, then a young man of twenty-two, left England as assistant surgeon and botanist to the Antarctic expedition of Sir J. C. Ross. During this memorable voyage, which lasted nearly four years, he collected the material and made the observations which after his return enabled him to prepare the "Flora Antarctica," the "Flora of New Zealand," and the "Flora of Tasmania." The six volumes comprising these works would alone have made the reputation of any naturalist; and upon them, as a broad and secure foundation, rests all subsequent work on the botany of the temperate portion of the Southern Hemisphere. Every New Zealand botanist owes a debt of gratitude for these magnificent volumes, wonderful in point of view of accuracy, originality of treatment, and fullness of detail. And the subsequently issued "Handbook of the New Zealand Flora," in which Hooker included all fresh matter received up to the time of publication, made no inconsiderable addition to the already heavy load of indebtedness.

Hooker's other botanical work has not the same intimate connection with New Zealand, although its magnitude and importance are indisputable. All I need mention here are his memoirs on *Nepenthes*, *Welwitschia*, and *Balanophora;* his papers and addresses on geographical distribution; his monumental "Flora of British India"; and, in co-operation with Mr. Bentham, the invaluable "Genera Plantarum." A full list of his contributions to systematic botany would fill many pages.

As Director of Kew, Hooker was able to use his unequalled knowledge of plants and great powers of organization to the very best advantage. The gardens were raised to a level never before attained, and were made the centre of the botanical work of the Empire, and the means of transmitting plants of economic value to all parts of the world. It has been well said that his connection with Kew added another great reputation to the great reputations he had already built up.

Whatever honours the scientific world could offer, those Sir Joseph Hooker has received. A member of almost all the chief learned societies in the world, the recipient of medals and decorations too numerous to particularize, the honour of knighthood, and the distinction of being selected as one of the first holders of the Order of Merit: it cannot be said that his labours have been without recognition. But his scientific work is the best monument to his memory, and will assuredly carry his name down to future ages. At the close of this address I propose to ask you to pass a resolution expressing our sense of the great and serious loss science has sustained in his death.

On the 30th January, 1908, the Board of Governors resolved that at each annual meeting the President should deliver an address. No theme or subject is particularized in the motion; but as the meeting is held primarily for business purposes, and

consequently must be largely concerned with the work performed by the Institute during the year, and must also take into consideration its financial position, it is obvious that it is the duty of the President to give those explanations that are necessary for a full knowledge of the doings of the society, and for the proper comprehension of its finances. I therefore propose to deal with these two matters first of all; after which I shall pass to some general considerations respecting the present position of the Institute and the various incorporated societies.

At the present time the chief work of the Institute lies in the publication of the annual volume of Transactions. I may therefore appropriately commence what I have to say with some brief remarks in reference to the volume—the forty-third of the series—which has been issued during the year. As members are aware, the Proceedings, although still separately issued, are now also bound up with the Transactions at the end of the year. The Transactions proper contain 680 pages and 32 plates (in addition to numerous figures in the text); the Proceedings extend to 128 pages. The entire volume thus comprises 808 pages, and is the largest single volume that has yet been issued by the Institute. In the previous year (1909) the Transactions covered 645 pages, and the separate Proceedings 160. In addition, two lengthy papers stretching over 104 pages were printed separately as Bulletins, the total publications for the year thus occupying no less than 909 pages.

I think it can be said that the recent volume of Transactions compares favourably with any of its predecessors. We all recognize that mere size has nothing to do with the value of any scientific publication; but an examination of the volume will prove to any unprejudiced observer that the quantity of matter contained in it has in no way depreciated in quality, and that the standard of merit of the various papers or memoirs is, on the whole, somewhat higher than in previous years. Personally, I think that one or two of the longer communications would have gained in value by judicious condensation; and I am inclined to doubt the expediency of admitting two others of great length and of a very different character from those usually printed. But these are minor matters and do not affect the value of the Transactions as a whole. I consider that the Editor and Publication Committee have discharged their duties in an efficient and admirable manner and deserve the hearty approval of the Board.

The index to the first forty volumes of the Transactions, first authorized at the meeting of the Board held on the 30th January, 1908, has been completed and printed. It has been compiled by Mr. Riddick, of the Government Printing Office, and consists of two parts—the first an index of authors, the second a classified catalogue of papers. The total cost of preparation and printing has been a little under £100. Those who have frequent occasion to use the Transactions will find the index a great convenience, and I am much surprised to hear that but few copies have been sold.

The report of the Publication Committee, which will be duly placed before you, contains several important suggestions, which will doubtless receive the careful consideration of the Board. I would particularly draw attention to a recommendation to the effect that theses for honours degrees should be pruned of all superfluous matter before being published in the Transactions. Most of us can recall instances where a regulation to the above effect would have been productive of much advantage.

In this place I regret to announce that in October Dr. Chilton resigned his position as Honorary Editor, on account of an approaching visit to Europe. With my concurrence, the Publication Committee arranged with Mr. R. Speight to act as Editor until the matter could be discussed by the Board.

I will now offer some remarks on the financial position of the Institute, which, I regret to say, is causing great anxiety to those who have the management of its affairs. Without entering into details, which will be found in the balance-sheet shortly to be placed before you, I will state that the amount to credit at the present time is about £390. Against this must be placed the sum due to the Government Printer for last year's Transactions and Proceedings, amounting to £545. The Institute is thus practically in debt to the extent of £155. Now, the reason for this very undesirable state of affairs is perfectly plain, and is doubtless known to all of you. It is simply due to the enlargement of the Transactions, to the separate issue and great amplification of the Proceedings, and to the occasional printing of Bulletins. If we inquire into the cost of the Transactions for the six years between 1902 and 1907 inclusive we shall find that it ranges from £350 to £480, the average being £414. If we take the three volumes of the new series—that is, Vols. 41 to 43—with their attendant publications, the result can be given as follows: Cost of Vol. 41, £441 9s. 3d.; of Vol. 42, £699 12s.; of Vol. 43, £545; the average for the three years being £565. In short, the average cost of the Transactions for the last three years is greater by £151 per annum than the average cost of printing the volume for the previous six years.

From the above it is evident that if the publications of the Institute are to be issued in a style comparable to that of the previous three years, then additional funds must be obtained. An increase in the statutory grant payable by Parliament would solve all difficulties and enable the Institute to print its Transactions in a proper and creditable manner. The present grant of £500 per annum dates from 1868, when the circumstances of the colony were very different from what they are now, and when the entire membership of the Institute amounted to only 178. At the present time there are no less than nine incorporated societies, all actively engaged in carrying out the objects of the Institute, each in accordance with its local requirements, and possessing a total membership of not less than 1,000. Their growth has naturally been accompanied by increased duties and responsibilities, which tax their resources to the utmost; but all such demands have been cheerfully met. On the other hand, notwithstanding the lapse of forty-five years and the altogether changed conditions, the Government grant is the same as in 1868. It is only reasonable that the subsidy should be made more proportionate to the amount raised by private subscription by the incorporated societies and expended on the purposes of the Institute.

During the last session of Parliament an attempt was made to induce the Government to enlarge the grant, but, from a variety of causes, no satisfactory result was obtained. Another application is now being made, which I trust will prove more successful. I would suggest that this meeting should consider what steps ought to be taken to support the proposal. The affiliated societies can exercise considerable influence on members of Parliament, and a concerted attempt, if carefully organized, would probably prove successful. In the meantime I should recommend that as large a portion as possible of the Government Printer's account should be paid, and that the rest should stand over until the fate of the application is known, or possibly until the receipt of the grant for this year.

The report of the Standing Committee, shortly to be placed before you, suggests certain savings in the expenditure, and alludes to a possible levy on the funds of the affiliated societies. I am strongly of opinion that such a course is altogether inadvisable, and should only be adopted as a last resource after all other plans have failed. It is to the affiliated societies that we must look for the progress of the Institute. They provide the material for the annual volume, they carry out the work of the Institute in their separate districts, and they have in most cases entered into obligations which absorb the whole of their income. To levy contributions upon them is to arrest progress and create dissatisfaction, without effecting any permanent improvement in the position of the Institute.

The separate publication of the Proceedings, and their great enlargement, are responsible for much of the increase in our printing bill. Most of us will cordially welcome the improvements in the Transactions proper; but I think it will be difficult, under present circumstances, to justify the additional expenditure on the Proceedings. After all, a considerable part of the material printed therein is of ephemeral value. Five years hence few people will be interested in the doings at the meetings of the various branches of the Institute, provided that all papers of permanent value are published in the Transactions. Something can be said in favour of printing notices of scientific memoirs relating to New Zealand published outside the Dominion, but even in that case there is little necessity for lengthy abstracts, the main point being to draw attention to the memoir, and to state where it can be seen in the Dominion. As for the publication of short papers in the Proceedings, if such possess any permanent value, they ought to form part of the Transactions, to which they properly belong, and where they would be naturally sought for. If, as appears to be the case, the funds at the disposal of the Institute are insufficient to print both Transactions and Proceedings in the style now being followed, then it is clearly with respect to the latter that retrenchment should take place.

Leaving the financial position of the society, there are still one or two matters upon which some remarks may be expected. In the first place, I have to announce that a branch of the Institute has been formed at Wanganui, and that you will be called upon to sanction its incorporation, the preliminary steps for which have been taken by the Standing Committee. Wanganui has already shown marked activity in scientific matters, as is evidenced by the establishment of a public Museum and the foundation of a small astronomical observatory. I am sure you will join with me in welcoming the new Wanganui Institute and assuring it of our good wishes for its future success.

While on the subject of the incorporated societies I ought, perhaps, to state that it is doubtful how far two of the number are complying with the regulations of the Institute. Notice of a motion on the subject has been given by Mr. Hamilton, and I trust that it will receive the careful consideration of the Board.

You are aware that the British Association is to meet in Australia towards the close of 1914, and that the New Zealand Government has very liberally voted the sum of £2,000 to cover the cost of bringing over a party of members from Australia after the close of the meeting, together with another party of well-known scientists from the United States and Canada. A supplementary meeting will then be held in New Zealand. Although it is almost certain that an arrangement will be made on the above lines, it is probable that the details will not be available until the close of 1913 or beginning of 1914. In the meantime, a reception committee has been formed, on which there is a full representation of the New Zealand Institute.

A few more words and I have finished. It is now nearly forty-five years since the New Zealand Institute Act became law and the Institute itself sprang into being. Although only a raw youth at the time, I was one of the original members; and I may perhaps be pardoned if I make a very few remarks on the growth of the Institute, its position at the present time, and what its aims should be in the future. I have never inquired as to who drafted the original New Zealand Institute Act, or who framed the first regulations issued under it; but whoever did so showed great foresight, and great knowledge of the springs of human action. He clearly recognized that the geographical configuration of the colony would effectually prevent the growth of one large centre like Sydney or Melbourne dominating and dwarfing all others, and that in its place there would be several widely separated towns, not far removed from one another, however, in size, in trade, and in relative importance. He therefore provided that the Institute should consist of distinct affiliated bodies. And as it was apparent that different portions of the colony would develop in different directions and under different circumstances, it naturally followed that the aims and objects of the various branches would be equally diverse. Hence the adoption of the important rule that the affiliated societies shall be entitled to retain or alter their own constitution, and shall conduct their own affairs. They are practically independent societies, bound together for the performance of a few common duties, but otherwise free to develop in any direction they may wish. Mr. Asquith, the Prime Minister of England, in a speech delivered at the time of the Imperial Conference, said that the problem to be solved in dealing with Imperial Federation was how to reconcile perfect autonomy with co-operation. I submit that forty-five years ago that question was settled so far as the scientific societies of New Zealand were concerned.

Two societies—the Wellington Philosophical Society and the Auckland Institute—were founded in 1868, within a few months of the passing of the Act. In the first year of their existence the members' roll numbered 178, the total revenue of the two societies being about £180. Five years afterwards, or in 1873, the number of societies had increased to five, with a membership of 563. At the present time there are nine incorporated societies, and the members' roll can be safely estimated at 1,000. The revenue derived from members' subscriptions exceeds £1,000, being thus double the amount of the Government grant. So far as mere membership is concerned, there is no reason to be dissatisfied with the progress of the Institute.

The primary object of the Institute was originally defined as being "to promote the cultivation of the various branches of art, science, literature, and philosophy." If it be asked what the Institute has done in the direction thus indicated, I should reply that a plain and sufficient answer is written on the pages of the forty-three volumes of the Transactions. I need not tell you that the Transactions contain an immense amount of information relating to the natural history, geology, physiography, and resources of the Dominion. No one can now study the flora or fauna of the Dominion, or undertake any investigation of a scientific nature respecting it, without frequent reference to the "Transactions of the New Zealand Institute." In short, as a repository and storehouse of information of a scientific and semi-scientific character relating to New Zealand the Transactions are unequalled, and in that respect alone have fully justified the formation of the Institute and the yearly subsidy granted by the Government.

If an inquiry be made as to the work done by the affiliated societies apart from the Transactions, an equally satisfactory reply can be given. Perhaps I may be allowed to say a few words in reference to the four leading branches of the Institute. In Canterbury we have a society surrounded by numerous local institutions tolerably well provided for. It has thus been able to confine its energies to the proper business of a scientific society, and in so doing has performed work of very great value. In proof of this I need only mention its enterprise in publishing Hutton's "Fauna Novæ Zealandiæ" and the Subantarctic reports. The Otago Institute follows very much the same lines, but in its recent formation of astronomical and technological branches is opening up an entirely new avenue of usefulness. In Auckland the Institute has undertaken the maintenance of the Auckland Museum, a work which taxes its resources to the utmost, and will do so for many years to come. It has,

however, succeeded in obtaining the hearty co-operation of the citizens, as is proved by the fact that nearly £20,000 has been either bequeathed or subscribed by private liberality for the endowment or advancement of the Museum. The Wellington Philosophical Society, if I may be allowed to say so, lags behind a little, and does not show a membership as numerous as should be the case in the capital city of the Dominion. This is much to be regretted, for it is to the Wellington Society that we must look for some local movement which will result in obtaining a permanent home for the library of the New Zealand Institute, and in rendering it available for the use of students.

As for the future, it lies in the hands of the affiliated societies. They are the Institute; their members prepare the papers to be published in the Transactions; their delegates form a majority of the Board of Governors; in their separate districts they keep alive the interest in the Institute. I see no reason why the Institute should not advance as well and as regularly in the future as in the past, provided that one little matter is kept in mind. It is this: Let the affiliated societies alone; make no attempt to tighten the framework which binds them together; avoid even the appearance of interfering with their local freedom. To again quote Mr. Asquith's words, our motto should be "Perfect autonomy, with co-operation."

AUCKLAND INSTITUTE.

FIFTH MEETING: *23rd October, 1911.*

Mr. J. H. Upton, President, in the chair.

New Members.—Messrs. L. W. Alexander, R. Hall, Dr. Marchesini.

Lecture.—"The Canterbury Plains and Banks Peninsula," by E. K. Mulgan, M.A.

In this lecture, which was copiously illustrated by lantern-views, the physical structure of the Canterbury Plains was fully described, and it was shown that the material composing the plains had been derived from the Southern Alps mainly at a time when the climatic and other conditions were more favourable than now for the supply and transportation of debris of all kinds. The lecture also explained the source of the artesian-water supply at Christchurch and elsewhere on the plains. The structure and formation of Banks Peninsula were then briefly described, and the lecturer showed how volcanic agencies could be proved to be responsible for the formation of Lyttelton Harbour and Akaroa Harbour. The lecture concluded with an account of the loess-deposits on Banks Peninsula and certain portions of the Canterbury Plains.

SIXTH MEETING: *28th November, 1911.*

Mr. J. H. Upton, President, in the chair.

New Members.—T. Finlayson, E. Gerard, Dr. P. A. Lindsay, T. F. Wallace.

Papers.—1. "Descriptions of New Native Species of Phanerogams," by D. Petrie, Ph.D.

2. "On *Danthonia nuda* and *Triodia Thomsoni*," by D. Petrie, Ph.D.

3. "New Genera and Species of *Coleoptera*," by Major T. Broun.

4. "On a New Genus and some New Species of Plants," by T. F. Cheeseman, F.L.S.

5. "List of Lichens and Fungi collected in the Kermadec Islands in 1908," by W. R. B. Oliver.

6. "The Geographic Relationships of the Birds of the Lord Howe, Norfolk, and Kermadec Islands," by W. R. B. Oliver.

In illustration of the last paper Mr. Oliver exhibited an interesting series of lantern-views, based on photographs obtained by him in the Kermadec Islands in 1908, and which clearly showed how largely the Islands are used as a breeding-place by certain species of petrels, terns, &c. He also gave many interesting particulars respecting the habits of the various species.

Professor A. P. W. Thomas spoke in commendation of the paper. He pointed out that it was one of the results of a scientific expedition made to the Kermadec Islands by a party of naturalists who were isolated there for eleven months. It was exceedingly satisfactory to find that there was sufficient enthusiasm in the pursuit of natural science to bring about such an expedition, and to produce such satisfactory results.

ANNUAL MEETING: *26th February, 1912.*

Mr. J. H. Upton, President, in the chair.

Annual Report.—The annual report and audited financial statement were read to the meeting, and ordered to be printed and circulated amongst the members.

ABSTRACT OF REPORT.

Membership.—It is satisfactory to state that there has been a considerable influx of new members, the elections during the year numbering forty-eight. On the other hand, fourteen names have been removed from the roll—four from death, eight from resignation, and two from non-payment of subscriptions for more than two consecutive years. The total number of members on the roll at the present time is 235, of whom twelve are life members and 223 annual subscribers. Among the members removed by death, the Council regret to mention the names of Messrs. J. Kirker, W. Gorrie, D. L. Murdoch, and T. Ching. It is hoped that the increase in the number of members will be maintained during the coming year, and will continue to keep pace with the advancing prosperity of the city.

Finance.—Full particulars respecting the financial position of the Institute will be found in the balance-sheet appended to this report. The total revenue of the Working Account, including the balance in hand at the commencement of the year, has been £1,273 5s. 10d. This is slightly more than £100 in excess of the income for the previous year, which was £1,170 11s. Examining the separate items, it will be seen that the Museum endowment has yielded in rents and interest on investments the sum of £527 12s. 3d. The revenue from the invested funds of the Costley Bequest has been £392 7s. 6d. The increase in the number of members has naturally led to a corresponding advance in the amount received for annual subscriptions, which stand at £208 19s. The total expenditure has been £1,197 14s., leaving a cash balance of £219 13s. 8d. in the Bank of New Zealand. The special fund subscribed by the citizens of Auckland for the purchase of historic Maori carvings and other objects will be alluded to in another portion of the report. The Council have no changes to report respecting the invested funds of the Institute, the total amount of which—£16,379 4s. 3d.—is the same as that announced last year.

Meetings.—In last year's report it was stated that it had been found necessary to engage St. Andrew's Hall, Symonds Street, for holding the meetings of the Institute. This arrangement has been continued during the year, and, on the whole, has proved satisfactory, both from the point of view of the suitability of the hall and the attendance of members and others. In all, six meetings have been held, at which the following lectures and papers were read and discussed :—

1. Presidential address, "Free Public Libraries and Museums," by J. H. Upton.
2. "Sources of Plague in Auckland, and its Prevention," by R. H. Makgill, M.D.
3. "Heredity," by Professor A. P. W. Thomas, M.A.
4. "Whirling Discs and their Uses," by Professor F. D. Brown, M.A.
5. "The Canterbury Plains and Banks Peninsula," by E. K. Mulgan, M.A.
6. "Description of New Native Species of Phanerogams," by D. Petrie, Ph.D.
7. "On *Danthonia nuda* and *Triodia Thomsoni*," by D. Petrie, Ph.D.
8. "New Genera and Species of *Coleoptera*," by Major T. Broun, F.E.S.
9. "On a New Genus and some New Species of Plants," by T. F. Cheeseman, F.L.S.
10. "List of Lichens and Fungi collected in the Kermadec Islands in 1908," by W. R. B. Oliver.
11. "The Geographic Relationships of the Birds of the Lord Howe, Norfolk, and Kermadec Islands," by W. R. B. Oliver.

Most of the above papers have been forwarded to Wellington for insertion in the forthcoming volume of Transactions.

Museum.—With the exception of the ten days devoted to the usual annual cleaning and rearrangement, the Museum has been open to the public daily throughout the year. The attendance of visitors continues to be satisfactory.

The year has been one of considerable activity in the Museum, and the progress made must be regarded as satisfactory. Numerous additions have been made to the collections, as will be seen from the appended lists, and several of them are of more than ordinary importance. Those selected for exhibition have been carefully and artistically mounted by Mr. Griffin, and have added much to the attractiveness of the institution.

The most noteworthy additions to the zoological department of the Museum are as follows : A series of 103 bird-skins from the Kermadec Islands, purchased from Mr. Roy Bell. A small collection of bird-skins from the Chatham Islands has also been purchased from Mr. Dannefaerd, containing several species (as, for instance, *Spheneacus rufescens*) now almost, if not altogether, extinct. Special mention should be made of a fine specimen of a male ostrich in full plumage, presented by the Helvetia Ostrich Company. Thanks are due to Mr. Hallyburton Johnstone for his kindness in specially collecting several New Zealand birds required to fill up blanks in the collections or to replace worn-out examples. Finally, Mr. Pickering has placed the Museum under many obligations by presenting a magnificent specimen of the twelve-wired bird of paradise, one of the finest species of the family.

In the geological and mineralogical department the only addition of importance is an extensive series of specimens illustrating the geology of the Waihi-Tairua Subdivision, Cape Colville Peninsula, very kindly presented by the Geological Survey Department, per Mr. Colin Fraser.

Turning to the ethnographical portion of the Museum, mention should be made of the figurehead of H.M.S. "Virago," presented by the Admiralty through the kind efforts of Archdeacon Walsh. Under the head of the Maori collections the thanks of the Institute are due to Mr. G. Graham for a historic greenstone pendant dating back to the times of the Waiohua, the former inhabitants of the Auckland Isthmus, also for a greenstone knife or saw used for cutting up human flesh, and for several other articles of interest. Contributions have also been received from Mr. Hallyburton Johnstone, Mr. Vaile, Mr. J. Macmillan, Mr. Curtis, Mr. Condron, and others.

The chief addition to the Maori collections, however, and to the Museum generally, consists of a series of ancient historic carvings from the East Cape district, purchased for the Museum only a few weeks ago, and, as they are remarkably good examples of the best period of Maori workmanship, their value from an ethnographical point of view is very great, and the Council consider that the Museum is to be congratulated on their acquisition.

Library. — The Mackechnie Library Bequest has yielded its usual income of slightly more than £100. A sum of £75 from the general funds of the Institute has been applied to the purchase of the serial publications regularly subscribed to, and in binding. Under this last head ninety-two volumes have been added to the library during the year. The usual exchanges and presentations have been received from foreign societies, together with some donations from private individuals.

As the numerous additions made to the library of late years had absorbed the whole of the shelf-room, a new press, capable of accommodating 800 volumes, has been erected.

Enlargement of the Buildings.—As guardians of the Museum and of the scientific library of the Institute, the Council cannot conclude this report without calling attention to some of the drawbacks and deficiencies which will impede the future development of the Museum and library unless additional accommodation can be provided, or, in other words, an enlargement of the buildings obtained. It is perhaps not generally known that in order to provide room for new acquisitions large numbers of specimens are being withdrawn from exhibition and packed away.

Granted the necessity of enlargement, the question of funds at once arises. To this it should be replied that such funds ought to be drawn from the public revenue, the course which has been followed in the southern portion of the Dominion.

In Auckland the total amount of the contributions made by the Government since 1875 is considerably below £4,000. Without in any way objecting to the expenditure on southern museums, the Council maintains that the amount so far expended on the Auckland Museum is entirely disproportionate, and should be rectified as soon as possible. They commend the facts quoted above to the earnest consideration of all those who deal with public affairs in Auckland, and they trust that the just claims of the Museum will receive that attention which they undoubtedly deserve.

Election of Officers for 1912.—President—Professor H. W. Segar; *Vice-Presidents* — J. H. Upton, Dr. R. Briffault; *Council* — Professor F. D. Brown, Professor C. W. Egerton, E. V. Miller, E. Mitchelson, T. Peacock, J. A. Pond, J. Reid, J. Stewart, Professor A. P. W. Thomas, H. E. Vaile; *Trustees*—Professor F. D. Brown, T. Peacock, J. Reid, J. Stewart, J. H. Upton; *Curator and Secretary*—T. F. Cheeseman; *Auditor*—S. Gray.

WELLINGTON PHILOSOPHICAL SOCIETY.

ANNUAL GENERAL MEETING: *4th October, 1911.*

Mr. G. V. Hudson, President, in the chair.

New Members.—Mr. Thomas Ward, A.M.Inst.C.E., Professor G. W. von Zedlitz, Mr. Barclay Hector, Mr. E. K. Lomas, M.A., M.Sc., Rev. J. Crewes, Major-General A. I. Godley, Colonel E. S. Heard, Mr. J. W. Macdonald, Mr. W. Turnbull, Mr. J. A. Bartrum, M.Sc.

The Council's report for the session, and a statement of the receipts and payments, were read, and, on the motion of Mr. A. Hamilton, seconded by Mr. G. Hogben, both were adopted. The report was as follows:—

ANNUAL REPORT.

The session opened on the 10th May with an inaugural address by the President, Mr. G. V. Hudson, on the value of natural-history subjects.

During the session no less than forty-eight papers have been read, and a number of interesting exhibits have been brought before the Society.

In addition to the six ordinary meetings, a special meeting was held at Victoria College, when Professor Laby lectured on the principles of gyroscopic motion, and exhibited his working model of the Brennan mono-rail, which, with other apparatus used in the lecture, had been constructed in the College laboratory.

Another special meeting will be held in October, when a lecture will be delivered on the finger-print system by officers of the Police Department.

The Astronomical Section has shown marked activity, and has now purchased an equatorial mounting for the 5 in. Cooke telescope. It will be erected and an observatory will be built at Kelburne as soon as the necessary formalities are completed.

The Society notes with pleasure the successful formation of the Eugenics Education Society of Wellington, and also of the Wanganui Philosophical Society.

The Society made strong representations to the Government to reserve the whole of Kapiti Island for native fauna and flora.

The question of tidal observations at the outlying islands has advanced another stage, and it is probable that arrangements will soon be made by the Government for observations to be taken at Suva, Fiji.

Since the last annual meeting twenty-four new members have been elected, nine have resigned, two have died, and one has been struck off the roll for non-payment of subscription. The total number on the roll is now 145, including six life members and one honorary member.

A statement of the receipts and expenditure for the year ended 30th September, duly audited, is presented with this report. Inclusive of the balance brought forward from last year (£55 7s. 5d.), the receipts amounted to £172 9s. 5d., and the total payments were £108 15s. 3d., leaving a credit balance of £63 14s. 2d. The life subscriptions have been placed to the credit of a special fund, which has been invested at interest with the Public Trustee. This fund now amounts to £20, and the Research Fund, also invested with the Public Trustee, amounts to £39 10s. 2d., making a total sum in hand of £123 4s. 4d.

From the Librarian's report it will be seen that the Society, by purchase or donation, receives over twenty scientific periodicals, but that only about ten of them are taken out by members.

The President announced that the following officers were suggested by the Council for the year 1912:—

Election of Officers for 1912.—President—Mr. G. V. Hudson; *Vice-Presidents*—Mr. Thomas King and Dr. C. Monro Hector; *Council*—Mr. F. G. A. Stuckey, Professor D. K. Picken, Rev. D. Kennedy, D.D., Professor T. H. Easterfield, Mr. A. Hamilton, Mr. Martin Chapman, K.C., Professor H. B. Kirk; *Secretary and Treasurer*—Mr. C. E.

Adams; *Librarian*—Miss J. A. Wilson; *Auditor*—Mr. E. R. Dymock. As no other nominations were made, Mr. A. Hamilton proposed that the officers as suggested by the Council be elected; seconded by Mr. P. G. Morgan, and carried.

Astronomical Section.—The annual report of the Astronomical Section was read by the Secretary, Mr. A. C. Gifford, and reference was made to the generous gift by Mrs. W. F. Parsons of a 6 in. reflecting telescope made by the late Mr. W. F. Parsons in 1873.

REPORT.

The Council has pleasure in reporting that substantial progress has been made during the year.

A fine equatorial mounting and pillar have been procured from Messrs. Cooke and Sons for the 5 in. refracting telescope.

Mrs. Parsons, of the Lower Hutt, has presented to the Society the 6 in. reflecting telescope which was made by the late Mr. W. F. Parsons in 1873.

Throughout the year strenuous efforts have been made by the Council to secure permission to build on the site at Kelburne. A succession of technical difficulties barred the way, but on the 9th October formal permission was received for the Society to occupy and build upon a quarter of an acre of the Observatory Reserve.

The Council endeavoured to organize a party to co-operate with the Australian expedition sent to observe the total eclipse of the sun in April last. Unfortunately, the difficulties in the way proved insuperable.

At the meetings of the section a number of important papers have been read and delivered.

On the 15th November, 1910, Professor T. H. Laby gave a lecture on "The Pressure of Light," illustrating his remarks with numerous experiments.

On the 21st February, 1911, Mr. W. S. La Trobe read a paper on "The Mechanism of Astronomical Instruments." The paper was illustrated by a fine collection of lantern-slides.

On the 11th April Professor D. K. Picken lectured on "Spherical Geometry and Trigonometry."

On the 13th June Mr. E. D. Bell read a paper on the "Magellan Clouds."

On the 18th July Mr. C. W. Adams lectured on the "Almucantar System of Observation and Kindred Methods."

On the 2nd September the Section and their friends, on the invitation of Mr. C. E. Adams, Astronomical Observer, met at the Hector Observatory, and the method of obtaining true time for the Dominion was fully explained.

On the 10th October the annual meeting of the Section was held. The Council was elected as follows: President—Mr. C. P. Powles; Vice-Presidents—Dr. C. M. Hector, the Rev. Dr. Kennedy, Professor D. K. Picken, and Mr. Martin Chapman; Council—Messrs. G. Hogben, C. E. Adams, W. S. La Trobe, H. Sladden, C. G. G. Berry, E. Parry, and Captain G. S. Hooper; Secretary—Mr. A. C. Gifford.

After the business of the annual meeting Dr. C. M. Hector read a paper on "The Milky Way."

Papers.—1. "Earthquake Origins in the South-west Pacific," with lantern illustrations of the San Francisco Earthquake," by G. Hogben, M.A., F.G.S.

2. "The Prevention of Cancer and other Diseases," by C. W. Adams.

3. "Harmonic Analysis of Tidal Observations," by C. E. Adams.

4. Annual report of Astronomical Section.

5. "Typical Sections showing the Junction of the Amuri Limestone and Weka Pass Stone at Weka Pass," illustrated by photographs, by C. A. Cotton.

ABSTRACT.

The photographs exhibited would serve to render intelligible the controversy concerning the nature of the junction between the Weka Pass stone and Amuri limestone. The sections photographed were those relied on by Hutton in proof of his theory of unconformity; the junction was exposed on each side of a narrow gorge cut by a small stream through the outcrop of the Weka Pass stone a few chains north of the railway viaduct in Weka Pass. The controversy which for many years engaged the attention of New Zealand geologists was to be found in a number

of papers in the Quar. Jour. Geol. Soc., the Trans. N.Z. Inst., and the Reports of the N.Z. Geological Survey. Hutton, on the one side, in accordance with his theory of unconformity, described the Weka Pass stone, an argillaceous limestone, glauconitic near the base, as resting, without change of dip, on a broken and fissured surface of Amuri limestone, and containing rounded pebbles of Amuri limestone within 6 in. of the junction, but not higher. On the other side, Hector and McKay, contending for conformity, pointed out the constant, shattered character of the Amuri limestone throughout its thickness, and explained the rounded pieces of limestone as concretions. There seemed no sufficient reason to regard the junction as unconformable, but, in view of the importance of the sequence at Waipara and Weka Pass in New Zealand geology, a satisfactory explanation of its peculiar character would be welcome.

6. "Description of a Multiple Rainbow," by G. L. Adkin.

Abstract.

In the clear atmosphere of mountain regions optical atmospheric phenomena such as sunset glows, rainbows, and halos frequently attain a brilliancy and degree of splendour seldom seen from stations at lower levels. The multiple rainbow seen on the 4th January, 1911, from the summit of Mount Waiopehu, 3,588 ft. (a peak on the western slope of the Tararua Ranges), is a case in point. Looking westward on the occasion referred to, the state of the atmosphere was such that Mount Egmont, 120 miles away, and the details—inlets, capes, islands, and hills—of the Marlborough Sounds, eighty miles distant, were remarkably clear and distinct.

The rainbow made its appearance at 5 p.m. The sun was low down in the western sky when a small, isolated rain-shower drove up from the south, swept across the summit of the mountain, and travelled rapidly northward, there furnishing the watery "curtain" necessary for the production of the bow. On account of the local character of the shower, only a portion of the arch became visible; nevertheless, its unusual breadth and brilliancy made it a very noticeable object.

The rainbow consisted of four parts—(1) the primary bow; (2) the secondary bow; (3) the supernumerary bow, situated on the inside of the primary, and consisting of the three outside colour-bands of the latter—*i.e.*, red, yellow, and green—three times repeated; and (4) the reflection of the supernumerary bow—a red glow situated on the outside of the secondary bow. The primary and supernumerary bows formed a continuous series of colour-bands, the repetition of the colours giving the whole a corrugated appearance.

7. "Notes on Life-history and Habits of some New Zealand *Lepidoptera*," by R. M. Sunley.

8. "Radio-activity of Thermal Waters of New Zealand," by Dr. J. S. Maclaurin.

9. "Radio-activity of Sea-water," by Dr. J. S. Maclaurin.

10. "Notes on New Zealand *Lepidoptera*, with Lists of New Localities and Observations on the Variations noted in certain Species," by A. Hamilton.

11. "Note on the Composition of Nitric Acid," by H. Fathers; communicated by Professor Easterfield.

12. "On the Use of Phosphorus and Phosphoric Acids for Cryoscopic Determinations," by G. Fulton; communicated by Professor Easterfield.

13. "Totarol," by J. C. McDowell; communicated by Professor Easterfield.

14. "The Genotypes of *Clavigera*, *Rastilligera*, and *Psioidea*," by J. Allan Thomson.

15. "Descriptions of New Species of *Lepidoptera*," by E. Meyrick.

16. "A Revision of the *Caradrinina*," by E. Meyrick.

17. "Wellington Physiography," by C. A. Cotton.

18. "On the Chemistry of Bush Disease," by B. C. Aston.

19. "Seismographical Records of Earthquakes in New Zealand, 1906–1911," by G. Hogben.

20. "The Phases of Manganic Sulphate," by G. H. Robertson; communicated by Professor Easterfield.

21. "On the Circulatory System of *Heptatrema cirrata*," by Professor Kirk.

22. "On Kermadec Island Sponges; Second Paper," by Professor Kirk.

23. "Montan Wax," by T. Rigg; communicated by Professor Easterfield.

SPECIAL MEETING: *1st November, 1911.*

Mr. Martin Chapman, K.C., in the chair.

The Chairman introduced Chief Detective McIlveney and Mr. E. Dinnie, of the criminal registration section of the Police Department, who gave an interesting lecture, illustrated by many fine lantern-slides, on the finger-print system for the detection of criminals.

The lecture was listened to with close attention, and on its conclusion the lecturers were heartily thanked.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

SEVENTH MEETING: *1st November, 1911.*

Present: Mr. R. M. Laing, Vice-President, in the chair, and seventy others.

New Members.—Messrs. F. M. Corkill and J. T. McBride.

Papers.—1. "Some Notes on the Botany of the Spenser Mountains," by R. M. Laing.

This paper was extensively illustrated with lantern-slides.

2. "The Methods of snaring Birds used by the Maoris," by J. Drummond, F.L.S., F.Z.S.

ABSTRACT, WITH NOTES ON A BIRD KNOWN TO THE MAORIS AS "TIAKA."

In August, 1911, I visited a Maori named Paitini, who lives at Ruatahuna, in the heart of the Urewera country. He is nearly seventy years old, and the object of my visit was to obtain from him, at first hand, information in regard to the ancient methods of snaring birds, which he learnt when he was a boy, before guns had come into general use for killing birds in that part of New Zealand. In conversation, he mentioned a bird, which he said was the same as the kakapo (*Stringops habroptilus*), only smaller, called the tiaka. The Ven. Archdeacon Williams, of Gisborne, in his list of Maori bird-names in the "Journal of the Polynesian Society," December, 1906, gives "tiaka" as the name applied to the leader of a flight of kakas (*Nestor meridionalis*), but Paitini had another bird in his mind. When I submitted Paitini's statements to Mr. Elsdon Best he informed me that "tiaka" is the name applied by North Island Maoris to the leader of a flock of kakapos. Each flock, it is stated, had its "tiaka," which is believed to have been always a small bird. It was supposed to lead or precede the flocks when they searched for food or returned from their feeding-grounds. Mr. Best adds that it was also believed that at night kakapos gathered at their *whawharua*, or playground, where they went through a performance like that of the American grouse, beating their wings on the ground. The tiaka, apparently, was believed to be on guard, or was the manager, as it walked around the edge of the place while the performance was held. Another belief was that kakapos collected hinau and tawa berries and fern-root (aruhe), and placed them in water-holes for future use. Maoris have told Mr. Best that kakapos were formerly found on the ranges near Ohau, in the Horowhenua County, but disappeared from there about three generations ago. They were also found on the Whakatangata Range, in the densely wooded district north of Maunga-taniwha, west of the headwaters of the Waiau tributary of the Wairoa River, a wild, broken, forest country. Evidently, at one time, they were fairly plentiful in a large part of the North Island, but disappeared from most of their haunts in that part of the country before the arrival of Europeans. I am unable to supply any theory as to the cause of their disappearance, which is a mystery.

Exhibits.—Mr. S. Page exhibited and described a collection of specimens of native clematis, making special reference to the great variation in the flowers and leaves of *C. indivisa*.

Dr. Moorhouse exhibited a specimen of the same species, showing abnormal coloured growths due to parasitic fungi.

ANNUAL MEETING: *6th December, 1911.*

Present: Mr. A. M. Wright, President, in the chair, and thirty others.

New Member.—Mr. T. Norris Baker.

Annual Report.—The annual report and balance-sheet for the year were adopted.

ABSTRACT.

The membership of the Institute has reached its highest for many years, and the finances are in consequence in a healthy condition. The Artesian Wells Committee has important results to show as the result of the energetic investigations of

several of its members, and Dr. Hilgendorf will read to-night an instructive paper on the variation of the wells near Lincoln. Messrs. George Gray and A. M. Wright have also been conducting analyses of well-waters; the height-observations have been resumed at the Museum, and similar observations have been begun by Mr. Langford P. Symes at Belfast, in order to measure the effect, if any, of the height of the Waimakariri on the levels of the wells in that locality.

The readings at the Otira Tunnel are still being continued, with the assistance of Mr. Manson of the Public Works Department, but at present they are not yielding results of any striking interest.

Kapiti Island.—The Council has always considered it a duty to constantly urge the importance of preserving the native fauna and flora of New Zealand, and when it was suggested that Kapiti Island, one of the Dominion's sanctuaries, could with advantage be used as a holiday resort for Wellington, the Council made strong representations to the Government as to the retrograde nature of the proposed step, and had the satisfaction of eliciting from the acting Minister of Lands a statement that it was not intended to interfere in any way with the position of the island as a sanctuary.

Survey of the Continental Shelf.—The Council also urged on the Government the desirability of using the s.y. "Terra Nova" in investigating the biological and hydographical problems of the New Zealand continental shelf. Its representations were not accepted, but it is to be hoped that the work which has been done by the "Terra Nova" in the waters immediately to the north of New Zealand may result in substantial additions to our scientific knowledge of the marine fauna of that area, as well as to conduce to the safety of shipping between Australia and this country.

Library.—The library has been kept up to date as far as has been possible, and the Council has been fully alive to the necessity of keeping up the Antarctic library, and volumes have been added thereto by presentation and by purchase as the funds have allowed. The most notable addition has been the reports of the Gauss Expedition, the expenditure on which has already exceeded £40.

Meetings of the Institute.—Eight meetings of the Institute have been held during the year, at which the average attendance has been sixty-six. At these, fourteen papers embodying the results of original work have been received. These may be classified as follows: Chemistry, 1; Zoology, 5; Botany, 4; Geology, 1; Mathematics, Miscellaneous, 3. In order to provide members with information of more general interest, the following addresses have been delivered during the year: "A Study in Multiple Personality" (ex-Presidential address), by Mr. R. M. Laing; "The Natural History of Whales," by Mr. D. G. Lillie, biologist to the "Terra Nova"; "Recent Advances in Radio-activity," by Mr. D. C. H. Florance; "Bogs and their Bearing on Climate," by Mr. R. Speight; "The Modification of Deep-sea Fish to suit their Environment," by Mr. Edgar R. Waite; "Profit-sharing," by Mr. A. W. Beaven.

Membership.—During the year twenty-six members have been elected and fourteen have resigned or been struck off, so that the number now stands at 183.

Balance-sheet.—The balance-sheet shows a credit on the Institute's ordinary account of £17 19s. 6d., in the hands of the London agent £29 14s., and in the Tunnel Account £142 19s. 10d. A sum of £113 19s. 10d. has been spent on the library, and £150 has been paid to the Government Printer on account of the expenses in connection with the publishing the "Subantarctic Islands of New Zealand"; the receipts for the year from the sale of the work has been £93 7s., and the amount still owing to the Government Printer has been reduced to £350.

Election of Officers for 1912.—The following were elected officers: *President* — Dr. L. Cockayne; *Vice-Presidents* — Mr. A. M. Wright, Mr. S. Page; *Hon. Secretary* — Dr. C. Coleridge Farr; *Hon. Treasurer*—Mr. R. Speight; *Hon. Librarian*—Mr. Edgar R. Waite; *Council*—Mr. J. Drummond, Mr. M. C. Gudex, Mr. P. H. Powell, Dr. F. W. Hilgendorf, Mr. E. G. Hogg, Mr. R. M. Laing; *representatives on the Board of Governors of the New Zealand Institute*—Dr. F. W. Hilgendorf, Mr. R. Speight; *Hon. Auditor*—Mr. G. E. Way, F.I.A.N.Z.

Papers.—1. "Fluctuations in the Water-level of some Artesian Wells in the Christchurch Area," by Dr. F. W. Hilgendorf.

2. "Notes on New Zealand Fishes, Part III," by Edgar R. Waite.

3. "The Lower Waipara Gorge," by R. Speight.

4. "Classification of Verse, Part II," by Johannes C. Andersen.

5. "On certain Tripolar Relations," by E. G. Hogg.

OTAGO INSTITUTE.

SEVENTH MEETING: *7th November, 1911.*

Present: Mr. A. Bathgate, President, in the chair, and twenty others.

Papers.—1. "On the Unconformable Relationship of the Lower Tertiary and Upper Cretaceous Formations of New Zealand," by Professor J. Park, F.G.S.

2. "On the Occurrence of Hydraulic Limestone on Otago Peninsula," by Professor J. Park, F.G.S.

3. "Some Rare Basic Nepheline Rocks from Waihola and Omimi," by Professor P. Marshall, D.Sc., F.G.S.

Exhibits.—Dr. Marshall exhibited portions of fossil remains of—(1) a large fish, from the Chains Hills Tunnel; (2) Mauisaurus, from Amuri Bluff; also original sketches by the late Major Heaphy, V.C., including portraits of Rauparaha and Rangihaeata.

Addresses.—1. "Protein-consumption in New Zealand," by Professor J. Malcolm.

2. "The Habits of the Fern-bird," by Dr. R. V. Fulton.

ANNUAL MEETING: *5th December, 1911.*

Mr. A. Bathgate, President, in the chair.

Annual Report.—The annual report and balance-sheet were adopted.

ABSTRACT.

Work of the Council.—The Council has met ten times for the transaction of the business of the Institute, of which the following is a summary:—

Your Council co-operated with the Canterbury Philosophical Institute in endeavouring to induce the Government to utilize the services of the "Terra Nova" in exploring the continental shelf off the coast of New Zealand. A deputation from the Council waited upon the Hon. J. A. Millar, Minister of Marine, on the occasion of one of his visits to Dunedin, and placed before him the desires of your Council. Your Council is pleased to report that the vessel was employed by the Government in marine survey work in our northern waters, and the results of this work will doubtless be made public in due time.

Your Council was approached in April last by the newly formed Dunedin Technological Society with a view to the latter body becoming amalgamated with, or affiliated to, the Institute. The matter was carefully gone into by committees appointed by the two societies, and in the end the Technological Society accepted affiliation to the Institute under the following conditions: (1) That the Institute provide for a Technological Branch having control over its own lectures and proceedings, and with power to select a chairman and other officers to manage the same; (2) that the Institute set aside a reasonable sum per annum for the use of the Technological Branch. Your Council at a later stage empowered the branch to incur expenses up to twenty guineas per annum without reference to the Council. This branch of the Institute is to be congratulated on the vigour and enthusiasm with which it has carried out its first year's programme, and at present it shows every sign of developing into a permanent and successful feature of the Institute.

Later in the year your Council was approached in a similar way by the Otago Astronomical Society. After a somewhat protracted consideration of the position by

both bodies, this society has also become affiliated to the Institute, under practically the same conditions as did the Technological Society, and now forms the Astronomical Branch of the Otago Institute. The Astronomical Society's special equipment fund, consisting of moneys specifically set apart for the purpose of buying astronomical apparatus, has been maintained by your Council as an equipment fund for the Astronomical Branch, and all future donations made towards this fund are to be similarly set apart. Your Council has set apart a sum of £95 for the purpose above specified.

As the financial position of the New Zealand Institute has latterly become a matter of grave concern, your Council, at the invitation of that body, took steps to enlist the sympathy and co-operation of the local members of the Legislature in an endeavour to procure an increased grant from the Government. Unfortunately, the efforts of the members of Parliament who have had the matter in hand in Wellington have not been successful. The Government, however, is to be approached again in the matter next year.

During the year the Council took in hand the revision of the constitution and rules of the Institute, and the results of its labours have been placed before the Institute and formally adopted. Several new clauses have been added to the constitution, the more important of them enabling the Institute to set up subcommittees for the management of such branches as the Astronomical and Technological Branches, and also to accept and set aside sums of money devoted to special purposes within the scope of the Institute's objects.

Your Council contributed five guineas to the Anton Dohrn Memorial Fund, and a similar amount to the Captain Cook Memorial Fund.

Towards the close of the year a subcommittee was appointed by the Council to consider the question of securing for the Institute a suitable building in which it might carry on its work more conveniently than at present, but no report from it has yet been received.

Ordinary Meetings.—Papers and addresses have been given by the President (Mr. A. Bathgate), Professor Malcolm, Dr. Fulton, Dr. S. Moore, and Messrs. G. W. Howes, H. D. Skinner, G. E. Thompson, E. E. Stark, and D. L. Poppelwell. A number of technical and scientific papers have been read and placed upon the table for publication in the Transactions. Interesting exhibits have been shown by Mr. Howes, Mr. Tannock, Professor Marshall, and Professor Benham.

In accordance with a custom that has obtained for some years past, your Council invited Mr. R. Speight, F.G.S., of the Christchurch Museum, to deliver an address before the members of the Institute. Mr. Speight chose for his subject "Remote and Unknown Canterbury," and the lecture, which was well illustrated with fine lantern-slides of the scenery of the high country in the Upper Rakaia basin, was delivered in the Early Settlers' Hall to a large and appreciative audience.

Addresses have been delivered before the Technological Branch by Professor Waters and Messrs. E. E. Stark, F. Oakden, F. W. Furkert, H. McRae, F. W. Payne, and M. Elliot. The Rev. D. Dutton delivered an address to the Astronomical Branch.

Membership. — The current session has, consequent upon the affiliation of the Technological and Astronomical Societies, witnessed an abnormally large increase in the membership of the Institute. The number of members on the roll at the close of last year was 134. During the year two members have resigned, and one member (Mr. W. McLeod) has been removed by death. On the other hand, 125 new members have joined the Institute, ninety of these coming in as members of the Technological and twenty-two as members of the Astronomical Branch, so that the membership now stands at 256. Five members of the Institute have during the year become life members. At the meeting of the Institute held on the 6th June Miss Edith Howes, of Gore, was elected an honorary member of the Institute in recognition of the literary excellence and scientific accuracy of her recent publication, "The Sun's Babies."

Library.—The Council have co-operated with the University Council in appointing Mr. H. D. Skinner to make a card catalogue of our library, which contains many books also belonging to the University and to the Museum, and to rearrange the books, which, owing to lack of room, have in several instances been placed temporarily in shelves apart from their proper locations. This desirable work will be carried on during the summer months.

Numerous additions by donation and purchase have been made during the year.

Balance-sheet.—The balance-sheet presented by the Treasurer (Mr. W. Fels) showed a credit of £64 11s. 1d. The receipts totalled £844 1s. 11d., including subscriptions amounting to £231. During the year a sum of £195 was placed on deposit at call with Hallenstein Bros. (Limited).

Election of Officers for 1912.—President—Professor W. B. Benham, D.Sc., F.R.S.; *Vice-Presidents*—Professor J. Malcolm, M.D., Mr. A. Bathgate; *Council*—Dr. R. V. Fulton, Professor P. Marshall, D.Sc., F.G.S., Professor D. B. Waters, Messrs. H. Brasch, F. W. Furkert, G. E. Thompson, M.A., G. M. Thomson, M.P., F.L.S.; *Hon. Treasurer*—W. Fels; *Hon. Secretary*—E. J. Parr, M.A., B.Sc.; *Hon. Librarian*—Dr. Benham; *Hon. Auditor*—D. Brent, M.A.; *Governors of the New Zealand Institute*—Professor P. Marshall and Mr. G. M. Thomson.

TECHNOLOGICAL SECTION.

SIXTH MEETING: *17th October, 1911.*

Mr. E. E. Stark in the chair.

Mr. F. W. Payne gave an explanatory lecture on "Dredge-construction."

SEVENTH MEETING: *21st November, 1911.*

Mr. E. E. Stark in the chair.

Mr. Michael Elliot, Engineer to the Taieri Drainage Board, gave a most interesting lecture on "Irrigation and Irrigation-works in Egypt."

After the lecture he exhibited some fine lantern-slides illustrating the engineering methods used in the various constructions—the Assouan Dam, the ruins on the Island of Philae, &c.

ASTRONOMICAL SECTION.

FIRST MEETING: *9th October, 1911.*

Rev. P. W. Fairclough in the chair.

The Rev. D. Dutton, F.G.S., F.R.A.S., gave an interesting address on "The Sun."

The lecture was fully illustrated by lantern-slides of the sun, with its corona and sun-spots, Jupiter, star-clusters, dead worlds, and worlds in the making.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

FIFTH MEETING: *3rd November, 1911.*

Dr. T. C. Moore, Vice-President, in the chair.

Address.—"Neglected Principles in Education," by Mr. W. Kerr, M.A.

The paper dealt with the crowded syllabus, harmonious development, differential education, methods of learning, and excessive correction.

ANNUAL MEETING: *11th December, 1911.*

Mr. Hill, B.A., President, in the chair.

New Members.—W. Oates, E. J. Humphreys, H. Bull, P. L. Poole.

Election of Officers for 1912.—President—Dr. T. C. Moore; *Vice-President*—W. Kerr, M.A.; *Secretary*—J. Niven, M.A., M.Sc.; *Treasurer*—J. Wilson Craig; *Council*—H. Hill, B.A., W. Dinwiddie, G. K. Sinclair, T. Hyde, G. Clark, W. Fossey; *Auditor*—J. S. Large; *Lanternist*—E. G. Loten; *Library Committee*—H. Hill, W. Dinwiddie; *representative on Board of Governors of New Zealand Institute*—H. Hill, B.A.

Annual Report.—The annual report and balance-sheet were read and adopted.

ABSTRACT.

Five meetings of the Institute and six meetings of the Council were held.

Six members were elected during the year. The membership now stands at eighty.

Twenty-three new works were added to the library, and the shelving accommodation was increased.

Four prizes were offered through the Agricultural and Pastoral Association for collections of plants, shells, seaweeds, and insects.

The Institute has a credit balance of £26 6s. 7d.

MANAWATU PHILOSOPHICAL SOCIETY.

SIXTH MEETING: *10th November, 1911.*

Captain Hewitt, R.N., in the chair.

The Chairman spoke of the removal of the Museum to the new premises, the use of which had been generously lent by the Borough Council, and of the great assistance which Mr. Hamilton had given in the arrangement of the collections.

Mr. Hamilton, after a brief reference to the history of the New Zealand Institute, and to the interest he had taken in the establishment of the Palmerston Branch, gave a very interesting lecture, illustrated by lantern-slides, on the "Arts and Crafts of the Maori."

He showed that the Maori, before the advent of the whites, was by no means—in the dictionary sense of the word—a savage, but possessed considerable knowledge not only of his own genealogies and tribal history, but also of natural history, astronomy, and the white magic found among other nations. Nor were they naturally a lazy race, but, apart from fighting, expended much time and labour on the cultivation of the ground and on the building and decoration of their houses and canoes, in which they displayed not only great excellence of execution, but a remarkable originality and absence of mechanical repetition in their designs. The education of those fitted by birth and mental powers to receive it was provided for in three "houses," in the first of which, open from dawn to noon, was taught genealogy and matters relating to the gods and the laws of *tapu;* in the second, open from noon to sunset, all that related to war; and in the third, open from dark to dawn, witchcraft and black magic. The breaking-up of the old system on the coming of Europeans and the destruction of the power of the chiefs had caused the loss of nearly all the knowledge and most of the virtues of the Maori, the introduction of money had done away with the necessity of labour, and European vices and clothing had introduced many diseases; but in the last ten years great improvements had taken place, and the prospect for the future was much brighter.

After the lecture a cordial vote of thanks was passed to Mr. Hamilton.

ANNUAL MEETING: *28th November, 1911.*

Captain Hewitt, R.N., in the chair.

Life Member.—In recognition of his services to the Society, Mr. Kenneth Wilson was elected a life member.

Annual Report.—The report and balance-sheet for the year were adopted.

ABSTRACT.

During the year four members have resigned, and sixteen new members have been elected, making our present number seventy-six.

The following papers were read during the year: "Report on Work at the Observatory," Captain Hewitt, R.N.; "Ramblings and a Little Philosophy," Mr. H. T. B. Drew; "The Astronomical Structure of New Zealand *Piperaceae*," Miss A. F. Ironside, M.A.; "Some New Zealand Moths." Rev. A. Doull, M.A.; "Moose and Wapiti in New Zealand," Mr. R. Henry; "Pike as Health Officers," Mr. R. Henry; "The Alpine Flora of New Zealand," Mr. Justice Chapman; "Notes on a Specimen of Volcanic Rock from Mount Erebus," Miss Souper; "Memory: What is it?" Sir R. Stout, K.C.M.G.; "Recent Local Weather," Mr. J. E. Vernon, M.A., B.Sc.; "The Arts and Crafts of the Maori," Mr. A. Hamilton.

The application for increased accommodation for the Museum, mentioned in last year's report, has been successful, and the Borough Council has very generously granted to the Society the use of the whole of the upper floor of the old Fire Brigade Building, has made necessary alterations therein, and put the whole in a state of thorough repair. Your Council has spent about £60 in providing the additional furniture required in the new building. All the collections have now been removed to the new building, and arranged and classified by Mr. A. Hamilton, Director of the Dominion Museum. The Society is deeply indebted to him for his very valuable help, to the borough authorities for the liberality with which they have met the wishes of the Council, and to the Curator, Mr. Hirtzel, for the great amount of care, time, and energy which he has given to the work of removal.

The Council specially desires to make the Museum illustrative of local products and industries, and with a view thereto has obtained a collection of New Zealand timber from Mr. Pegden and Messrs. Lewis and Kuhtze, with the promise of an exhibit showing all the processes of the flax industry from the Flax-millers' Association, one of wools from Messrs. Mellsop and Eliott, of New Zealand grasses from Mr. T. W. Kirk, F.L.S., and of grains and seeds from Messrs. Barraud and Abraham and Mr. Baylis of the Department of Agriculture. When all these are in place the collection will be one of which, considering its youth, neither the Society nor the town need be ashamed.

The balance-sheet shows that the receipts for the year amounted to £44 9s. 7d., and the expenditure £110 4s. 9d. The assets are valued at £523 14s. 10d., while the liabilities stand at £66 0s. 2d., leaving a balance in favour of the Society of £455 14s. 8d.

Election of Officers for 1912.—President—Mr. R. Gardner; *Vice-Presidents*—Messrs. J. L. Barnicoat and E. J. Armstrong, C.E.; *Secretary and Treasurer*—Mr. K. Wilson, M.A.; *Officer in Charge of the Observatory*—Captain Hewitt, R.N.; *Council*—Messrs. W. E. Bendall, W. F. Durward, M. A. Eliott, F. Foote, B.Sc., R. McNab, and J. E. Vernon, M.A.; *Auditor*—Mr. J. Mitchell.

ABSTRACTS.

1. Monographie der Gattung Koeleria. By Dr. Karl Domin. With 22 plates and 3 maps. 4to. Stuttgart, 1907.

This elaborate monograph occupies four complete parts of Luersen's "Bibliotheca Botanica," and covers more than 350 quarto pages. It is divided into three main parts, the first dealing with the history and morphology of the genus; the second, which occupies by far the greater portion of the work, being devoted to the systematic arrangement of the species and their varieties; while the third is concerned with the facts of geographical distribution and the probable phylogeny of the species. The systematic portion is drawn up on most liberal lines. Previous writers have treated *Koeleria* as a small genus containing considerably less than a score of species. Hooker and Bentham, in the "Genera Plantarum," accepted twelve species, and Hackel, in "Die Naturlichen Pflanzenfamilien," only increased the number to fifteen. But Dr. Domin describes no less than sixty-one, and even then he is careful to state that several of these are "collective species," and that the full number is eighty-nine. Many of his "species" are further separated into subspecies, varieties, subvarieties, forms, &c. As an instance of the laboriously minute treatment adopted, it may be mentioned that the variable *K. gracilis* (the *K. cristata* of most authors) is divided by Domin into fourteen subspecies. The first of these is again separated into twelve groups, which are further split up into forty-four varieties. Altogether, Domin describes rather more than 170 forms of *Koeleria gracilis*, his account of that species alone occupying sixty-five pages of his monograph! It may be asked to what extent a monograph of the New Zealand species of *Veronica* would stretch if prepared on similar lines.

New Zealand botanists have been accustomed to include all our *Koelerias* within the compass of a single species, which for many years was considered to be a form of *K. cristata*. When preparing the Manual I followed Hackel's views in referring our plant to a South American species distinguished by him as *K. Kurtzii* (equivalent to *K. Bergii* Hierony, according to Domin); but Dr. Domin considers that we have three endemic species in New Zealand. These he places with six South American, two Australian, and two Asiatic species in a group to which he gives the name of *Dorsoaristatae*. The following key to the New Zealand species is adapted from his work :—

Awn dorsal.
Small, culms not creeping at the base ... 1. *K. novozealandica.*
Larger, culms creeping at the base ... 2. *K. superba.*
Awn strictly terminal ... ... 3. *K. Gintlii.*

The first of these species is based upon specimens collected by Dr. Cockayne in the Otira Gorge; *K. superba* was gathered by myself on the mountains above the Broken River, Canterbury; and *K. Gintlii* in the Hooker Valley, Mount Cook district.

Although it is impossible not to feel that the multiplication of species has been carried to an inordinate degree, there are many points of excellence in Domin's memoir; and it can fairly be said that it contains much original work of a high order, and that he has treated his subject in a most complete and exhaustive manner.

T. F. C.

2. Monographie der Gattung Taraxacum. By Dr. H. F. von Handel-Mazetti. 4to. Leipzig, 1907.

In the "Genera Plantarum" Hooker and Bentham remarked that about forty species of *Taraxacum* had been described, and that some authors reduce these to six. Hoffman, in "Die Naturlichen Pflanzenfamilien," gave the number of valid species at from twenty to twenty-five, and more recent writers have made various estimates, ranging from twenty to forty-five. Dr. Handel-Mazetti, who is generally acknowledged to be the leading authority on the genus, admits no less than fifty-seven, contained in eleven sections. Forty-two of the species are found in Asia, twenty-eight in Europe, three in Africa, six in North America, two in Australia, and one in New Zealand (in addition to the introduced *T. vulgare*). The New Zealand

species was first observed by Banks and Solander, who applied the manuscript name of *Leontodon glabratum* to it. Hooker associated it with the introduced *T. officinale* Wigg (*T. vulgare* Schrank). Kirk, in the "Students' Flora," separated it as a variety, under the name of *glabratus*, while more recently Dr. Cockayne has given it full specific honours as *Taraxacum glabratum*. Neither Kirk nor Cockayne appears to have compared our plant with the South American *T. magellanicum* Comm., which ranges from Chile to Fuegia and the Falkland Islands. Dr. Handel-Mazetti, however, has done this in a very complete manner, and has satisfactorily established the identity of the two plants, which must in future bear the name of *T. magellanicum*. He points out that *T. magellanicum* can be readily distinguished from *T. vulgare* (*T. officinale*) by the outer bracts of the involucre being broad, conspicuously margined, and always erect and appressed. In *T. vulgare* the exterior bracts are linear, not margined, and usually reflexed.

Dr. Handel-Mazetti's monograph must be regarded as an excellent example of careful and painstaking systematic work, and will probably long remain the standard authority on the genus. T. F. C.

APPENDIX.

NEW ZEALAND INSTITUTE ACTS.

NEW ZEALAND INSTITUTE ACT, 1903.

The following Act reconstituting the Institute was passed by Parliament :—

1903, No. 48.

AN ACT to reconstitute the New Zealand Institute.

[*18th November, 1903.*

WHEREAS it is desirable to reconstitute the New Zealand Institute with a view to connecting it more closely with the affiliated institutions :

Be it therefore enacted by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows :—

1. The Short Title of this Act is the New Zealand Institute Act, 1903.

2. The New Zealand Institute Act, 1867, is hereby repealed.

3. (1.) The body hitherto known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as may hereafter be incorporated in accordance with regulations to be made by the Board of Governors as hereinafter mentioned.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

4. The control and management of the Institute shall be in the hands of a Board of Governors, constituted as follows :—

The Governor ;

The Colonial Secretary ;

Four members to be appointed by the Governor in Council during the month of December, one thousand nine hundred and three, and two members to be similarly appointed during the month of December in every succeeding year ;

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year ;

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year.

5. (1.) Of the members appointed by the Governor in Council two shall retire annually on the appointment of their successors ; the first two members to retire shall be decided by lot, and thereafter the two members longest in office without reappointment shall retire.

(2.) Subject to the provisions of the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

6. The Board of Governors as above constituted shall be a body corporate, by the name of the "New Zealand Institute," and by that name they shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

7. (1.) The Board of Governors shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) It shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) It shall have power to make regulations under which societies may become incorporated to the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with, and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property hereinafter vested in it, and of any additions hereafter made thereto, and shall make regulations for the management of the same, for the encouragement of research by the members of the Institute, and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

8. Any casual vacancy on the Board of Governors, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board of Governors.

9. (1.) The first annual meeting of the Board of Governors hereinbefore constituted shall be held at Wellington on some day in the month of January, one thousand nine hundred and four, to be fixed by the Governor, and annual meetings of the Board shall be regularly held thereafter during the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board of Governors may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

10. The Board of Governors may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in the colony by any means that may appear desirable.

11. The Colonial Treasurer shall, without further appropriation than this Act, pay to the Board of Governors the annual sum of five hundred pounds, to be applied in or towards payment of the general current expenses of the Institute.

12. (1.) On the appointment of the first Board of Governors under this Act the Board of Governors constituted under the Act hereby repealed shall cease to exist, and the property then vested in, or belonging to, or under the control of that Board shall be vested in His Majesty for the use and benefit of the public.

(2.) On the recommendation of the President of the Institute the Governor may at any time hereinafter, by Order in Council, declare that any part of such property specified in the Order shall be vested in the Board constituted under this Act.*

13. All regulations, together with a copy of the Transactions of the Institute, shall be laid upon the table of both Houses of Parliament within twenty days after the meeting thereof.

NEW ZEALAND INSTITUTE ACT, 1908

1908, No. 130.

AN ACT to consolidate certain Enactments of the General Assembly relating to the New Zealand Institute.

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. (1.) The Short Title of this Act is the New Zealand Institute Act, 1908.

(2.) This Act is a consolidation of the enactments mentioned in the Schedule hereto, and with respect to those enactments the following provisions shall apply:—

(*a.*) The Institute and Board respectively constituted under those enactments, and subsisting on the coming into operation of this Act, shall be deemed to be the same Institute and Board respectively constituted under this Act without any change of constitution or corporate entity or otherwise; and the members thereof in office on the coming into operation of this Act shall continue in office until their successors under this Act come into office.

(*b.*) All Orders in Council, regulations, appointments, societies incorporated with the Institute, and generally all acts of authority which originated under the said enactments or any enactment thereby repealed, and are subsisting or in force on the coming into operation of this Act, shall enure for the purposes of this Act as fully and effectually as if they had originated under the corresponding provisions of this Act, and accordingly shall, where necessary, be deemed to have so originated.

(*c.*) All property vested in the Board constituted as aforesaid shall be deemed to be vested in the Board established and recognized by this Act.

(*d.*) All matters and proceedings commenced under the said enactments, and pending or in progress on the coming into operation of this Act, may be continued, completed, and enforced under this Act.

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* See *New Zealand Gazette*, 1st September, 1904.

2. (1.) The body now known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as heretofore have been or may hereafter be incorporated therewith in accordance with regulations heretofore made or hereafter to be made by the Board of Governors.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

3. The control and management of the Institute shall be vested in a Board of Governors (hereinafter referred to as "the Board"), constituted as follows:—

The Governor:

The Minister of Internal Affairs:

Four members to be appointed by the Governor in Council, of whom two shall be appointed during the month of December in every year:

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine:

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

4. (1.) Of the members appointed by the Governor in Council, the two members longest in office without reappointment shall retire annually on the appointment of their successors.

(2.) Subject to the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

5. The Board shall be a body corporate by the name of the "New Zealand Institute," and by that name shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

6. (1.) The Board shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) The Board shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) The Board shall have power from time to time to make regulations under which societies may become incorporated with the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with; and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property from time to time vested in it or acquired by it; and shall make regulations for the

management of the same, and for the encouragement of research by the members of the Institute; and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

7. (1.) Any casual vacancy in the Board, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board.

(2.) Any person appointed to fill a casual vacancy shall only hold office for such period as his predecessor would have held office under this Act.

8. (1.) Annual meetings of the Board shall be held in the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

9. The Board may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in New Zealand by any means that may appear desirable.

10. The Minister of Finance shall from time to time, without further appropriation than this Act, pay to the Board the sum of five hundred pounds in each financial year, to be applied in or towards payment of the general current expenses of the Institute.

11. Forthwith upon the making of any regulations or the publication of any Transactions, the Board shall transmit a copy thereof to the Minister of Internal Affairs, who shall lay the same before Parliament if sitting, or if not, then within twenty days after the commencement of the next ensuing session thereof.

SCHEDULE.

Enactments consolidated.

1903, No. 48.—The New Zealand Institute Act, 1903.

REGULATIONS.

THE following are the regulations of the New Zealand Institute under the Act of 1903:—*

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by the New Zealand Institute Act, 1903.

INCORPORATION OF SOCIETIES.

1. No society shall be incorporated with the Institute under the provisions of the New Zealand Institute Act, 1903, unless such society shall consist of not less than twenty-five members, subscribing in the aggregate

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* *New Zealand Gazette*, 14th July, 1904.

a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

Publications.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications :—

(*a.*) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Board of Governors shall determine what papers are to be published.

(*c.*) Papers not recommended for publication may be returned to their authors if so desired.

(*d.*) All papers sent in for publication must be legibly written, typewritten, or printed.

(*e.*) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f.*) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

Management of the Property of the Institute.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of

Governors for public advantage, in like manner with any other of the property of the Institute.

7. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt, and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

8. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

9. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary of the Institute, may nominate for election as honorary member one person.

10. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

General Regulations.

11. Subject to the New Zealand Institute Act, 1908, and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

12. Upon application signed by the President and countersigned by the Secretary of any society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

13. In voting on any subject the President is to have a deliberate as well as a casting vote.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than the 30th November.

THE HUTTON MEMORIAL MEDAL AND RESEARCH FUND.

Resolved by the Board of Governors of the New Zealand Institute that—

1. The funds placed in the hands of the Board by the committee of subscribers to the Hutton Memorial Fund be called "The Hutton Memorial Research Fund," in memory of the late Captain Frederick Wollaston Hutton, F.R.S. Such fund shall consist of the moneys subscribed and granted for the purpose of the Hutton Memorial, and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding £100 shall be expended in procuring a bronze medal to be known as "The Hutton Memorial Medal."

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as aforesaid as may be approved of by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund.

5. The Hutton Memorial Medal shall be awarded from time to time by the Board of Governors, in accordance with these regulations, to persons who have made some noticeable contribution in connection with the zoology, botany, or geology of New Zealand.

6. The Board shall make regulations setting out the manner in which the funds shall be administered. Such regulations shall conform to the terms of the trust.

7. The Board of Governors may, in the manner prescribed in the regulations, make grants from time to time from the accrued interest to persons or committees who require assistance in prosecuting researches in the zoology, botany, or geology of New Zealand.

8. There shall be published annually in the "Transactions of the New Zealand Institute" the regulations adopted by the Board as aforesaid, a list of the recipients of the Hutton Memorial Medal, a list of the persons to whom grants have been made during the previous year, and also, where possible, an abstract of researches made by them.

Regulations under which the Hutton Memorial Medal shall be awarded and the Research Fund administered.

1. Unless in exceptional circumstances, the Hutton Memorial Medal shall be awarded not oftener than once in every three years; and in no case shall any medal be awarded unless, in the opinion of the Board, some contribution really deserving of the honour has been made.

2. The medal shall not be awarded for any research published previous to the 31st December, 1906.

3. The research for which the medal is awarded must have a distinct bearing on New Zealand zoology, botany, or geology.

4. The medal shall be awarded only to those who have received the greater part of their education in New Zealand or who have resided in New Zealand for not less than ten years.

5. Whenever possible, the medal shall be presented in some public manner.

6. The Board of Governors may, at an annual meeting, make grants from the accrued interest of the fund to any person, society, or committee for the encouragement of research in New Zealand zoology, botany, or geology.

7. Applications for such grants shall be made to the Board before the 30th September.

8. In making such grants the Board of Governors shall give preference to such persons as are defined in regulation 4.

9. The recipients of such grants shall report to the Board before the 31st December in the year following, showing in a general way how the grant has been expended and what progress has been made with the research.

10. The results of researches aided by grants from the fund shall, where possible, be published in New Zealand.

11. The Board of Governors may from time to time amend or alter the regulations, such amendments or alterations being in all cases in conformity with resolutions 1 to 4.

Award of the Hutton Memorial Medal.

1911. Professor W. B. Benham, D.Sc., F.R.S., University of Otago—For researches in New Zealand zoology.

Grant from the Hutton Memorial Research Fund.

1911. To Professor C. Chilton, Canterbury College—£10 for the preparation of illustrations for a revision of the *Crustacea* of New Zealand.

HECTOR MEMORIAL RESEARCH FUND.

Declaration of Trust.

This deed, made the twenty-seventh day of January, one thousand nine hundred and twelve, between the New Zealand Institute, a body corporate duly incorporated by the New Zealand Institute Act, 1908, of the one part, and the Public Trustee, of the other part: Whereas the New Zealand Institute is possessed of a fund consisting now of the sum of one thousand and forty-five pounds ten shillings and twopence (£1,045 10s. 2d.), held for the purpose of the Hector Memorial Research Fund on the terms of the rules and regulations made by the Governors of the said Institute hereinafter set forth: And whereas the said money has been transferred to the Public Trustee for the purposes of investment, and the Public Trustee now holds the same for such purposes, and it is expedient to declare the trusts upon which the same is held by the Public Trustee:

Now this deed witnesseth that the Public Trustee shall hold the said moneys, and all other moneys which shall be handed to him by the said Governors, for the same purposes upon trust from time to time, to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules hereinafter set forth.

And it is hereby declared that it shall be lawful for the Public Trustee to pay, and he shall pay, all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed so to do by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute, enclosing a copy of such resolution, certified by him and by the President as correct, shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy, the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year first hereinbefore written.

Rules and Regulations made by the Governors of the New Zealand Institute in relation to the Hector Memorial Research Fund.

1. The funds placed in the hands of the Board by the Wellington Hector Memorial Committee be called "The Hector Memorial Research Fund," in memory of the late Sir James Hector, K.C.M.G., F.R.S. Such fund shall consist of the moneys subscribed and granted for the purpose of the memorial, and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding one hundred pounds (£100) shall be expended in procuring a bronze medal, to be known as "The Hector Memorial Medal."

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as may be approved by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund.

5. The Hector Memorial Medal and Prize shall be awarded annually by the Board of Governors.

6. The research for which the medal and prize are awarded must have a distinct bearing on New Zealand—(1) Botany, (2) chemistry, (3) ethnology, (4) geology, (5) physics (including mathematics and astronomy), (6) zoology (including animal physiology).

7. Whenever possible the medal shall be presented in some public manner.

The seal of the New Zealand Institute was hereto affixed, the 27th day of January, 1912, in the presence of—

T. F. Cheeseman, President.
B. C. Aston, Secretary.

Signed by Frederick Fitchett, the Public Trustee, and sealed with the seal of his office.

Award of the Hector Memorial Research Fund.

1912. L. Cockayne, Ph.D.—For researches in New Zealand botany.

NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND UNDER THE NEW ZEALAND INSTITUTE ACT, 1903, AND CONTINUED BY THE NEW ZEALAND INSTITUTE ACT, 1908.

Board of Governors.

EX OFFICIO.

His Excellency the Governor.
The Hon. the Minister of Internal Affairs.

NOMINATED BY THE GOVERNMENT.

A. Hamilton, F.L.S. (December, 1911); E. Tregear, F.R.G.S. (December, 1910); John Young, (December, 1911); Charles A. Ewen (December, 1910).

ELECTED BY AFFILIATED SOCIETIES (DECEMBER, 1911).

Wellington Philosophical Society ...	Martin Chapman, K.C. Professor H. B. Kirk, M.A.
Auckland Institute	D. Petrie, M.A., Ph.D. J. Stewart, C.E.
Philosophical Institute of Canterbury ...	F. W. Hilgendorf, M.A., D.Sc. R. Speight, M.A., M.Sc., F.G.S.
Otago Institute	Professor Marshall, D.Sc., F.G.S. G. M. Thomson, M.P., F.C.S.
Hawke's Bay Philosophical Institute ...	H. Hill, B.A., F.G.S.
Nelson Institute	L. Cockayne, Ph.D., F.L.S.
Manawatu Philosophical Society ...	K. Wilson, M.A.
Wanganui Philosophical Society ...	W. Hesse, B.A.

OFFICERS FOR THE YEAR 1912.

President: T. F. Cheeseman, F.L.S., F.Z.S.

Hon. Treasurer: C. A. Ewen.

Joint Hon. Editors: R. Speight, M.A., M.Sc., F.G.S.; F. W. Hilgendorf, M.A., D.Sc.

Secretary: B. C. Aston, F.I.C., F.C.S.
(Box 40, Post-office, Wellington.)

AFFILIATED SOCIETIES.	DATE OF AFFILIATION.
Wellington Philosophical Society	10th June, 1868.
Auckland Institute	10th June, 1868.
Philosophical Institute of Canterbury ...	22nd October, 1868.
Otago Institute	18th October, 1869.
Westland Institute	21st December, 1874.
Hawke's Bay Philosophical Institute ...	31st March, 1875.
Southland Institute	21st July, 1880.
Nelson Institute	20th December, 1883.
Manawatu Philosophical Society	16th January, 1904.
Wanganui Philosophical Society	25th January, 1912.

FORMER HONORARY MEMBERS.

1870.

Agassiz, Professor Louis.
Drury, Captain Byron, R.N.
Flower, Professor W.H., F.R.S.
Hochstetter, Dr. Ferdinand von.
Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., O.M.
Mueller, Ferdinand von, M.D., F.R.S., C.M.G.
Owen, Professor Richard, F.R.S.
Richards, Rear-Admiral G. H.

1871.

Darwin, Charles, M.A., F.R.S.
Gray, J. E., Ph.D., F.R.S.
Lindsay, W. Lauder, M.D., F.R.S.E.

1872.

Grey, Sir George, K.C.B.
Huxley, Thomas H., LL.D., F.R.S.
Stokes, Vice-Admiral J. L.

1873.

Bowen, Sir George Ferguson, G.C.M.G.
Cambridge, the Rev. O. Pickard, M.A., C.M.Z.S.
Lyell, Sir Charles, Bart., D.C.L., F.R.S.

1874.

McLachlan, Robert, F.L.S.
Newton, Alfred, F.R.S.
Thomson, Professor Wyville, F.R.S.

1875.

Filhol, Dr. H.
Rolleston, Professor G., M.D., F.R.S.

1876.

Clarke, Rev. W. B., M.A., F.R.S.
Etheridge, Professor R., F.R.S.

1877.

Baird, Professor Spencer F.
Weld, Frederick A., C.M.G.

1878.

Garrod, Professor A. H., F.R.S.
Müller, Professor Max, F.R.S.
Tenison-Woods, Rev. J. E., F.L.S.

1880.

The Most Noble the Marquis of Normanby, G.C.M.G.

1883.

Carpenter, Dr. W. B., C.B., F.R.S.
Ellery, Robert L. J., F.R.S.
Thomson, Sir William, F.R.S.

1885.

Gray, Professor Asa.
Sharp, Richard Bowdler, M.A., F.R.S.

1888.

Beneden, Professor J. P. van.
Ettingshausen, Baron von.
McCoy, Professor F., D.Sc., C.M.G. F.R.S.

1890.

Riley, Professor C. V.

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1900.

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Geological Survey of the United Kingdom, London.
High Commissioner for New Zealand, London.
Imperial Institute, London.
Institution of Civil Engineers, London.
International Catalogue of Scientific Literature, London.
Leeds Geological Association, Meanwood, Leeds.
Linnæan Society, London.
Literary and Philosophical Society, Liverpool.
Liverpool Biological Society.
Marine Biological Association of the United Kingdom, Plymouth.
Natural History Society, Glasgow.
" Marlborough College, England.
Nature, The Editor of, London.
Norfolk and Norwich Naturalist Society, Norwich.
North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.
Patent Office Library, London.
Philosophical Society of Glasgow.
Philosophical Society of Leeds, England.
Royal Asiatic Society, London.
Royal Botanic Garden Library, Edinburgh.
Royal College of Physicians, Edinburgh.
Royal Colonial Institute, London.
Royal Geographical Society, London.
Royal Irish Academy, Dublin.
Royal Physical Society, Edinburgh.
Royal Society, Dublin.
" Edinburgh.
" London.
Royal Society of Literature of the United Kingdom, London.
Royal Statistical Society, London.
School Library Committee, Eton, England.
" Rugby, England.
University Library, Cambridge, England.
" Edinburgh.
" Oxford, England.
Victoria College, Manchester.
Victoria Institute, London.
William Wesley and Son, London (Agents).
Zoological Society, London.

British North America.

Canadian Institute, Toronto.
Geological and Natural History Survey of Canada, Ottawa.
Hamilton Scientific Association, Hamilton, Canada.
Institute of Jamaica, Kingston.
Literary and Historical Society of Quebec, Canada East.
Natural History Society of New Brunswick, St. John's.
Nova-Scotian Institute of Natural Science, Halifax.
Ottawa Literary and Scientific Society, Ottawa.

South Africa.

Free Public Library, Cape Town.
South African Philosophical Society, Cape Town.
South African Association for the Advancement of Science, Cape Town.
South African Museum, Cape Town.
Rhodesia Museum, Bulawayo, South Africa.

India.

Asiatic Society of Bengal, Calcutta.
Colombo Museum, Ceylon.
Geological Survey of India, Calcutta.
Natural History Society, Bombay.
Raffles Museum, Singapore.

Queensland.

Geological Society of Australasia, Queensland Branch, Brisbane.
Geological Survey Office, Brisbane.
Library, Botanic Gardens, Brisbane.
Queensland Museum, Brisbane.
Royal Society of Queensland, Brisbane.

New South Wales.

Agricultural Department, Sydney.
Australasian Association for the Advancement of Science, Sydney.
Australian Museum Library, Sydney.
Department of Mines, Sydney.
Engineering Association of New South Wales, Sydney.
Library, Botanic Gardens, Sydney.
Linnæan Society of New South Wales, Sydney.
Public Library, Sydney.
Royal Geographical Society of Australasia, N.S.W. Branch, Sydney.
Royal Society of New South Wales, Sydney.
University Library, Sydney.

Victoria.

Australian Institute of Mining Engineers, Melbourne.
Field Naturalists' Club, Melbourne.
Geological Survey of Victoria, Melbourne.
Gordon Technical College, Geelong.
Legislative Library, Melbourne.
Public Library, Melbourne.
Royal Society of Victoria, Melbourne.
University Library, Melbourne.
Victorian Institute of Surveyors.

Tasmania.

Public Library of Tasmania, Hobart.
Royal Society of Tasmania, Hobart.

South Australia.

Royal Society of South Australia, Adelaide.
University Library, Adelaide.

Russia.

Finskoie Uchonoie Obshchestvo, Finnish Scientific Society, Helsingfors.
Imper. Moskofskoie Obshchestvo Iestestvo - Ispytatelei, Imperial Moscow Society of Naturalists.
Kiefskoie Obshchestvo Iestestvo-Ispytatelei, Kief Society of Naturalists.

Norway.

Bergens Museum, Bergen.
University of Christiania.

Sweden.

Geological Survey of Sweden, Stockholm.
Royal Academy of Science. Stockholm.

Denmark.

Natural History Society of Copenhagen.
Royal Danish Academy of Sciences and Literature of Copenhagen.

Germany.

Botanischer Verein der Provinz Brandenburg, Berlin.
Königliche Bibliothek, Berlin.
Königliche Physikalisch-Oekonomische Gesellschaft, Königsberg, E. Prussia.
Königliches Zoologisches und Anthropologisch - Ethnographisches Museum, Dresden.
Naturhistorischer Verein, Bonn.
Naturhistorisches Museum, Hamburg.
Naturwissenschaftlicher Verein, Bremen.
Naturwissenschaftlicher Verein, Frankfort-an-der-Oder.
Rautenstrauch-Joest-Museum (Städtisches Museum für Völkerkunde), Cologne.
Redaktion des Biologischen Central-Blatts, Erlangen.
Senckenbergische Naturforschende Gesellschaft, Frankfurt-am-Main.
Verein für Vaterländische Naturkunde in Württemburg, Stuttgart.

Austria.

K.K. Central-Anstalt für Meteorologie und Erdmagnetismus, Vienna.
K.K. Geologische Reichsanstalt, Vienna.

Belgium and the Netherlands.

Musée Teyler, Haarlem.
Académie Royal des Sciences, des Lettres, et des Beaux-Arts de Belgique, Brussels.
La Société Royale de Botanique de Belgique, Brussels.

Switzerland.

Musée d'Histoire Naturelle de Genève.
Naturforschende Gesellschaft (Société des Sciences Naturelles), Bern.

France.

Bibliothèque Nationale, Paris.
Musée d'Histoire Naturelle de Bordeaux.
Musée d'Histoire Naturelle, Paris.
Société Entomologique de France, Paris.
Société de Géographie, Paris.
Société Zoologique de France, Paris.

Italy.

Biblioteca ed Archivio Tecnico, Rome.
Museo di Geologia e Paleontologia del R. Instituto di Studi Superiori, Florence.
Museo di Zoologia e di Anatomia Comparata della R. Universita, Turin.
Orto e Museo Botanico (R. Instituto di Studi Superiori), Florence.
R. Accademia di Scienze, Lettre, ed Arti, Modena.
R. Accademia dei Lincei, Rome.
Stazione Zoologica di Napoli, Naples.
Società Africana d'Italia, Naples.
Società Geografica Italiana, Rome.
Società Toscana di Scienze Naturali, Pisa.

United States of America.

Academy of Natural Sciences, Buffalo, State of New York.
" Davenport, Iowa.
" Library, Philadelphia.
" San Francisco.
American Geographical Society, New York.
American Institute of Mining Engineers, Philadelphia.
American Museum of Natural History, New York.
American Philosophical Society, Philadelphia.
Boston Society of Natural History.
Connecticut Academy, New Haven.
Department of Agriculture, Washington, D.C.
Field Museum of Natural History, Chicago.
Franklin Institute, Philadelphia.
Johns Hopkins University, Baltimore.
Missouri Botanical Gardens, St. Louis. Mo.
Museum of Comparative Zoology, Cambridge, Mass.
Natural History Museum, Central Park, New York.
New York Academy of Sciences.

Philippine Museum, Manila.
Rochester Academy of Sciences.
Smithsonian Institution, Washington, D.C.
Stanford University, California.
Tufts College, Massachusetts.
United States Geological Survey, Washington, D.C.
University of Montana, Missoula.
Wagner Free Institute of Science of Philadelphia.
Washington Academy of Sciences.

Brazil.

Museo Paulista, Sao Paulo.
Escola de Minas, Rio de Janeiro.

Argentine Republic.

Sociedad Cientifica Argentina, Buenos Ayres.

Uruguay.

Museo Nacional, Monte Video.

Japan.

College of Literature, Imperial University of Japan, Tokyo.
College of Science, Imperial University of Japan, Tokyo.

Hawaii.

Bernice Pauahi Bishop Museum, Honolulu.
National Library, Honolulu.

Java.

Society of Natural Science, Batavia.

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